

OCx CEM Interface Module Configuration Guide, Cisco IOS XE 17 (Cisco ASR 900 Series)

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CONTENTS

CHAPTER 1 **Feature History** 1

CHAPTER 2 **Preface** 7

Document Organization 7

Related Documentation 9

PART I **Overview of the OCx Interface Module** 11

CHAPTER 3 **Overview of the OCx Interface Module** 13

CHAPTER 4 **Support for OCx CEM Interface Modules** 17

Configuring Support of 1 port OC-48/STM-16 or 4 port OC-12/OC-3 / STM-1/STM-4 + 12 port T1/E1 + 4 port T3/E3 CEM Interface Module 17

Configuring Support of 1-Port OC-192 or 8-Port Low Rate CEM Interface Module 18

Configuring Support for ASR 900 1-Port OC-192 or 8-Port Low Rate CEM 20G Bandwidth Interface Module (A900-IMA1Z8S-CXMS) 18

Modes of Operation 19

Restrictions and Limitations for ASR 900 1-Port OC-192 or 8-Port Low Rate CEM 20G Bandwidth Interface Module (A900-IMA1Z8S-CXMS) 20

Features supported on OCx CEM Interface Module 22

Restrictions for Configuring OCx CEM Interface Modules 25

CHAPTER 5 **Port Licensing** 27

Information About Port Licensing 27

Installing a License 28

Enabling a License 28

Verifying License Configuration 29
Disabling a License 29
Uninstalling a License 29

PART II SONET and SDH 31

CHAPTER 6 Configuring SONET 33
Overview of SONET 33
Restrictions for SONET 34
SONET path BER threshold configuration guidelines 35
SONET Switching 36
SONET Hierarchy 37
Section 37
Line 37
Path 37
SONET Line and Section Configuration Parameters 38
SONET Path Level Configuration Parameters 38
SONET T1 Configuration Parameters 39
SONET T3 Configuration Parameters 39
SONET VT Configuration Parameters 39
How to Configure SONET 40
Prerequisites for Configuring SONET 40
Configuring MediaType Controller 40
Configuring SONET Ports 40
Managing and Monitoring SONET Line 40
Configuring Line and Section Overhead 40
Configuring Line Loopback 41
Configuring AIS Shut 41
Configuring Shut 41
Configuring Alarm Reporting 42
Configuring Clock 42
Configuring STS-1 Modes 42
Verification of SONET Configuration 43
Clearing the PMON Data 49

Configuring CEM Group for Framed SAToP 49
Configuring VT-15 mode of STS-1 for Framed SAToP 50
Configuring DS1/T1 CT3 mode of STS-1 for Framed SAToP 50
Performance Monitoring Use Cases or Deployment Scenarios for SONET 50
Configuring Port Rate and Verifying Pluggables 71
Configuring Port Rate for SONET 72
Verifying the Pluggables 72
Loopback Remote on T1 and T3 Interfaces 74
Restrictions for Loopback Remote 74
Configuring Loopback Remote in Sonet 74
Verifying the Loopback Remote Configuration 75
Configuring POS Scrambling 76
Associated Commands 77

CHAPTER 7 Configuring SDH 81
Overview of SDH 81
Basic SDH Signal 82
SDH Hierarchy 82
Modes of CEM 82
Services Provided by SDH Configuration 83
SDH Multiplexing 85
Modes of SDH 86
Configuring AUG Mapping 87
Configuring AU-3 or AU-4 Mapping 87
Configuring Mixed AU-3 and AU-4 Mapping 87
Verifying AUG Mapping Configuration 88
Configuring Modes under AU-4 Mapping 88
Configuring Mode VC-4 CEP 88
Configuring Mode TUG-3 89
Configuring Mode VC-1x 91
Configuring Mode VC-4 Nc 93
Configuring AU-3 — VC-3 — DS3 94
Configuring AU-3 — VC-3 — E3 94
Configuring Modes under AU-3 Mapping 94

Configuring Mode VC-1x 94
Configuring AU-4 — TUG-3 — TUG-2 — VC-12 for Framed SAToP 96
Configuring AU-3 — TUG-2 — VC-11 — T1 for Framed SAToP 97
Verifying SDH Configuration for Framed SAToP 97
Restrictions for SDH 98
Configuring Mediatype Controller 99
Configuring Rate on SDH Ports 99
SDH Line and Section Configuration Parameters 100
Overhead 100
Configuring Line and Section Overhead 100
Threshold 100
Configuring Line and Section Threshold 100
Loopback 101
Configuring Line Loopback 101
AIS-Shut 101
Configuring AIS Shut 101
Shutdown 102
Configuring Shut 102
Alarm Reporting 102
Configuring Alarm Reporting 103
Clock Source 103
Configuring Clock 103
Verifying SDH Line and Section Parameters Configuration 104
Configuring SDH Path Parameters 115
Path Overhead 115
Path Threshold 116
Path Loopback 117
Verifying Path Parameters Configuration 117
Configuring BERT in SDH for SAToP 118
BERT Patterns on 1-Port OC-48 or 4-Port OC-12/OC-3 CEM Interface Module 118
Configuring BERT in Modes VC-4 and VC Nc 119
Verifying BERT Configuration in Modes VC-4 and VC Nc 120
Configuring E1 Bert 120
Configuring T1 Bert 120

Configuring BERT in Mode T3/E3 121
Verifying BERT Configuration in Mode T3 or E3 121
Configuring BERT in Mode VC-1x 121
Verifying BERT Configuration in Mode VC-1x 121
SDH T1/E1 Configuration Parameters 122
Configuring T1/E1 Parameters 122
Verifying T1 or E1 Parameters Configuration 123
SDH T3/E3 Configuration Parameters 123
Configuring SDH T3/E3 Parameters Configuration 124
Verifying SDH T3 or E3 Parameters Configurations 124
SDH VC Configuration Parameters for SAToP 124
Configuring VC Parameters 125
Verifying VC Configuration Parameters Configurations 125
Configuring ACR on SDH 126
Verifying ACR Configuration on SDH 126
Configuring DCR on SDH 127
Verifying DCR Configuration on SDH 128
Loopback Remote on T1 and T3 Interfaces 128
Restrictions for Loopback Remote 128
Configuring Loopback Remote in SDH 128
Verifying the Loopback Remote Configuration 129
Performance Monitoring Use Cases or Deployment Scenarios for SDH 132

PART III **Interworking Multiservice Gateway** 143

CHAPTER 8 **Serial Interfaces** 145
Serial Interface Supported Modes 145
Interworking Multiservice Gateway Support Matrix 149
Creating T1 or E1 Serial Interfaces on T1 or E1 Ports 151
Creating T3 or E3 Serial Interfaces on T3 or E3 Ports 152
Creating an E1 Serial Interface in Unframed Mode 153
Creating Serial Interfaces on SDH 154
Creating Serial Interfaces on SONET 156
Modifying Encapsulation to PPP 157

IPv4 or IPv6 Interworking Multiservice Gateway Pseudowire over HDLC or PPP 158
L2VPN Interworking Multiservice Gateway 158
L2VPN iMSG Mode 158
IP Interworking Mode 158
HDLC or PPP to Ethernet IPv4 or IPv6 iMSG Pseudowire 159
IPv4 or IPv6 iMSG Pseudowire Supported Modes 159
Limitations of IPv4 or IPv6 iMSG Pseudowire on HDLC or PPP Serial Interfaces 159
How to Configure IPv4 or IPv6 iMSG Pseudowire on HDLC or PPP Interface 160
Configuring L2VPN iMSG 160
Configuring Cross-Connect Under Attachment Circuit 161
Verifying IPv4 or IPv6 iMSG Pseudowire over HDLC or PPP Configuration 161
IPv4 or IPv6 Interworking Multiservice Gateway Pseudowire over Frame Relay 164
Frame Relay for iMSG 164
Limitations of IPv4 or IPv6 iMSG Pseudowire on Frame Relay Serial Interfaces 165
Scale Supported for iMSG Pseudowire on Frame Relay Serial Interfaces 165
How to Configure IPv4 or IPv6 iMSG Pseudowire on Frame Relay Serial Interface 166
Modifying Encapsulation to Frame Relay 166
Configuring Frame Relay 166
Configuring L2VPN iMSG Using Local Connect for Frame Relay 168
Configuring L2VPN iMSG Using Cross Connect for Frame Relay 169
Verifying IPv4 or IPv6 iMSG Pseudowire over Frame Relay Configuration 170
Configuring Frame Relay for APS Protection 172
Configuring Frame Relay for UPSR Protection 172
Configuring Frame Relay L2VPN iMSG for APS Protection 173
Configuring Frame Relay L2VPN iMSG for UPSR Protection 173
Verifying Frame Relay for APS Protection 173
Verifying Frame Relay for UPSR Protection 174
Scenario 1–Configure L2VPN iMSG Using Local Connect for Frame Relay 176
Scenario 2–Configure L2VPN iMSG Using Cross Connect for Frame Relay 177
IPv4 Layer 3 Termination on HDLC or PPP Serial Interfaces 179
IPv4 Layer 3 Termination on HDLC or PPP Serial Interfaces 179
Restrictions for IPv4 Layer 3 Termination on HDLC or PPP Serial Interfaces 179
How to Configure IPv4 Layer 3 Termination on HDLC or PPP Serial Interfaces 179
Configuring Protocols 179

Configuring VRF 180
Configuring IPv4 Unicast Layer 3 Termination on HDLC or PPP Interfaces 180
Verifying IPv4 Layer 3 Termination on HDLC or PPP 181
QoS Support on Serial Interfaces 181

CHAPTER 9 **Interworking Multiservice Gateway Access Circuit Redundancy** 185
SONET Supported Modes 185
SDH Supported Modes 186
Restrictions for iMSG ACR 187
How to Configure iMSG ACR 187
Creating ACR Group 187
Configuring ACR Group on APS 188
Creating Serial Interface for SONET ACR 189
Creating Serial Interface for SONET ACR on VT 1.5 Mode 189
Creating Serial Interface for SONET ACR on CT3 Mode 190
Creating Serial Interface for SONET ACR on T3 Mode 190
Creating Serial Interface for SONET ACR on PoS Mode 190
Creating Serial Interface for SONET non-ACR on PoS Mode 190
Creating Serial Interface for SDH ACR 191
Creating Serial Interface for SDH ACR on PoS Mode 192
Creating Serial Interface for SDH non-ACR on PoS Mode 192
Modifying Encapsulation to PPP 192
Configuring IPv4 and IPv6 Interworking Pseudowire 192
Configuring Cross-Connect on Serial Interface 193
Verifying iMSG ACR 194
Verifying iMSG ACR with HDLC Encapsulation 194
Verifying iMSG ACR with PPP Encapsulation 195
Verifying iMSG ACR with HDLC Encapsulation on PoS Mode 196
Verifying iMSG ACR with PPP Encapsulation on PoS Mode 196

CHAPTER 10 **Multilink Interfaces** 199
MLPPP 199
Restrictions for MLPPP 199
How to Configure MLPPP 200

Configuring MLPPP 200
Configuring MLPPP ACR 201
Deleting Serial Interface from an Active MLPPP Bundle 201
Removing MLPPP Configuration 202
Verifying MLPPP Configuration 202
MLPPP Interworking 202
Restrictions for MLPPP Interworking 203
How to Configure MLPPP Interworking 203
Configuring L2VPN Interworking and Cross Connection under the Attachment Circuit for Multilink Interfaces 203
Verifying L2VPN Interworking and Cross-Connect Configuration 204
MLPPP Layer 3 Termination 206
Restrictions for MLPPP Layer 3 Termination 206
How to Configure MLPPP Layer 3 Termination 206
Configuring MLPPP Layer 3 Termination 206
MLPPP ACR Support for iMSG 207
Restriction for MLPPP ACR 207
Multilink PPP Minimum Links Mandatory 208
How to Configure Multilink PPP Minimum Links Mandatory 208
Configuring Multilink PPP Minimum Links Mandatory 208
Verifying the Multilink PPP Minimum Links Mandatory Configuration 208
Multilink Frame Relay 209
Limitations of IP Interworking on MFR Interfaces 210
How to Configure IP Interworking on MFR Interface 210
Configuring MFR 210
Configuring MFR ACR 212
Verifying MFR Configuration 213
Multilink Frame Relay Layer 3 Termination 214
Restrictions for MFR Layer 3 Termination 215
How to Configure MFR Layer 3 Termination 215
Configuring MFR Layer 3 Termination 215
Verifying MFR Layer 3 Termination 217
Multilink Frame Relay End-to-End Mode 218
How to Configure MFR End-to-End 218

Configuring MFR End-to-End 219
Verifying MFR End-to-End 222

CHAPTER 11 QoS on Layer 3 Terminated MLPPP Interfaces 225
Restrictions For Layer 3 Terminated MLPPP Interface 226
How to Configure QoS on Layer 3 Terminated MLPPP Interface 226
Configuring Classification 226
Enabling SDM Template 227
Configuring Policy Map 227
Configuring Shaping 228
Configuring Bandwidth 228
Configuring Bandwidth Remaining Percent 228
Configuring Bandwidth Remaining Ratio 228
Configuring Priority 229
Configuring WRED 229
Verifying QoS Configuration on Layer 3 Terminated MLPPP Interface 229

CHAPTER 12 VLAN Handoff 233
Overview of VLAN Handoff 233
IP Interworking Switching on Single Router 234
Restrictions for VLAN Handoff 234
Enabling the VLAN Handoff 234
Configuring VLAN Handoff for IPv4 Local Connect 235
Example - VLAN Handoff for IPv4 Local Connect 236
Configuring VLAN Handoff for IPv4 Cross Connect 237
Configuring VLAN Handoff for IPv6 Local Connect 239
Configuring VLAN Handoff for IPv6 Cross Connect 241

PART IV OCx Protection 245

CHAPTER 13 Automatic Protection Switching 247
1+1 APS 248
Benefits of APS 248
APS 1+1 for SONET Layer 1 traffic 249

Scenario for Bidirectional APS 1+1 249
Scenario for Unidirectional APS 1+1 249
Restrictions for APS 250
Configuring CEM APS for Framed SAToP 250
Verifying SONET Configuration for Framed SAToP 251
Provisioning APS 1+1 252
Deprovisioning APS 1+1 252
Configuring APS for SAToP 253
Configuring Bi-directional ACR (SONET Framing) 253
Configuring Unidirectional APS 254
Verifying ACR Configurations 254
Configuring VT 1.5-T1 Loopback 257
Configuring VT 1.5-T1 BERT 257
Configuring Path Overhead 257
Configuring Path Threshold 258
Monitoring Protection Switching Count for Protected SONET Interface 258

CHAPTER 14 **Configuring MSP** 265
1+1 MSP 265
Benefits of MSP 266
Restrictions for MSP 266
MSP 1+1 for SDH Layer 1 traffic 266
Scenario for Bidirectional MSP 1+1 267
Scenario for Unidirectional MSP 1+1 267
Configuring MSP for SAToP 267
Verifying MSP Configuration for SAToP 269
Configuring MSP for CESoPSN 270
Configuring CEM Group for MSP on Virtual ACR AU3-T1 in CESoPSN 270
Verifying CEM Group for MSP on Virtual ACR AU3-T1 in CESoPSN 271
Configuring CEM Group for MSP on Virtual ACR AU4-E1 in CESoPSN 271
Verifying CEM Group for MSP on Virtual ACR AU4-E1 in CESoPSN 272
Configuring Clocking ACR for MSP AU3-T1 in CESoPSN 272
Verifying Clocking ACR for MSP AU3-T1 in CESoPSN 273
Configuring Clocking DCR for MSP AU3-T1 in CESoPSN 273

Verifying Clocking DCR for MSP AU3-T1 in CESoPSN 274
Configuring Clocking ACR for MSP AU4-E1 in CESoPSN 274
Verifying Clocking ACR for MSP AU4-E1 in CESoPSN 275
Configuring Clocking DCR for MSP AU4-E1 in CESoPSN 275
Verifying Clocking DCR for MSP AU4-E1 in CESoPSN 276

CHAPTER 15 **UPSR Path Protection** 277
Restrictions for iMSG UPSR Path Protection 278
Configuring iMSG UPSR 278
Configuring UPSR 278
Configuring UPSR Work and Protection Path Configuration 279
Verifying UPSR Configuration 279

CHAPTER 16 **Unidirectional Path Switching Ring Over HDLC** 281
Unidirectional Path Switching Ring Over HDLC Overview 281
Limitations for HDLC UPSR 281
How to Configure UPSR over HDLC 282
Configuring Protection Group 282
Configuring Channel Group 282
Creating Protection Group Serial Interface for VT 1.5 T1 Mode 282
Creating Protection Group Serial Interface for T3 or STS-3c Mode 282
Creating Protection Group Serial Interface for VT 1.5 T1 Mode 283
Creating Protection Group Serial Interface for T3 or STS-3c Mode 283
Adding Protection Group to Controller Under VT 1.5 Mode 284
Adding Protection Group to Controller Under T3 Mode 284
Adding Protection Group to Controller Under STS-3c Mode 284
Configuring Cross-Connect Under Protection Group Serial Interface Pseudowire 284
Verifying UPSR Over HDLC Configuration 285
Configuration Examples for HDLC UPSR 285
Use Case 1 285
Use Case 2 286

CHAPTER 17 **Configuring SNCP** 289
Restrictions for SNCP 289

SNCP Path Protection 289
Configuring SNCP 290
Verification of SNCP Configuration 291

PART V DCC and TARP 293

CHAPTER 18 Configuring Data Communication Channel 295
Restrictions of DCC 297
Configuring PPP 297
Configuring CLNS or LAPD 298
Verification of DCC Configuration 298

CHAPTER 19 Transparent Overhead Tunneling Data Communication Channel 299
Transparent Overhead Tunneling Data Communication Channel Overview 299
Transparent Overhead Tunnel DCC Types 300
Prerequisites for Transparent Overhead Tunnel 301
Limitations of Transparent Overhead Tunnel 302
How to Configure Transparent Overhead Tunnel 303
Configuring Mode for Controller 303
Creating Transparent Overhead Tunnel 303
Configuring DCC Interface in IP Domain 304
Configuring TOH Tunnelling 304
Creating Transparent Overhead Tunnel Pseudowire 304
Verifying Transparent Overhead Tunnel and Pseudowire Configuration 304

CHAPTER 20 Target Identifier Address Resolution Protocol 307
Prerequisites for TARP Support 307
Restrictions and Limitations 307
Types of TARP PDU's 308
TARP Features 308
TARP Caching 308
TARP Timers 309
TARP Counters 309
NSAP Address Format 309

Determining TIDs and NSAPs 310
Understanding NSAP 310
How To Configure TARP 311
Enabling TARP and Configuring a TARP TID 311
TARP on Gigabit Ethernet Interface 312
TARP on SDCC 312
How to Configure TARP 313
TARP Configuration Examples 313
Configuring TARP Features 314
Configuring Static TARP Adjacency and Blacklist Adjacency 314
Configuring TARP Timers 314
Configuring Miscellaneous TARP PDU Information 315
TARP Configuration Task List 315
Disabling TARP Caching 316
Disabling TARP PDU Origination and Propagation 316

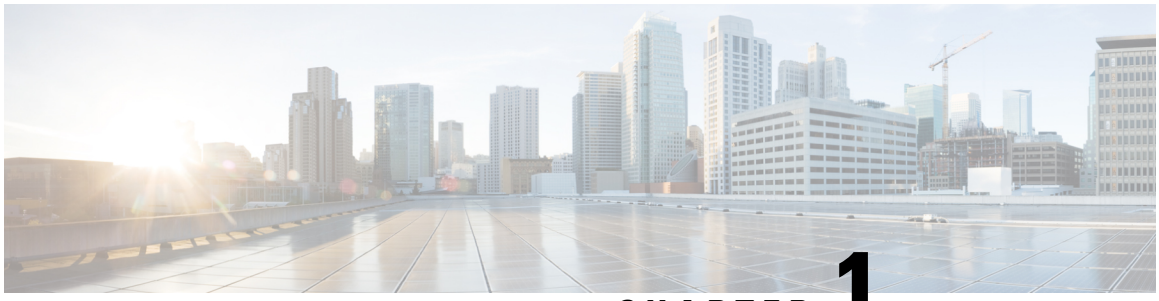
PART VI **Bandwidth for OCx Modules** 317

CHAPTER 21 **Configuring 5G Mode** 319
Supported Traffic Combinations 321
Restrictions for Configuring 1-Port OC-192/STM-64 or 8-Port OC-3/12/48/STM-1/-4/-16 Interface Module 322
Important Notes on Configuration 322
Configuring 5G Mode from 10G Mode 322
Configuring 10G Mode from 5G Mode 322
Verification of 5G Traffic Configuration 323
Associated Commands 323

PART VII **Additional References** 325

CHAPTER 22 **Additional References for SONET/SDH Frame Structures** 327
SONET Frame Structure 327
STS-1 and STS-3 Frames 327
Concatenated SONET Frames 328

Channelized SONET Frames 329
SDH Frame Structure 329
VC 330



CHAPTER 1

Feature History

The following table lists the new and modified features supported on the following OCx CEM Interface Module Configuration Guide, Cisco IOS XE 17 (Cisco ASR 900 Series).

The OCx Interface Modules supported are:

- 1-port OC-192 or 8-9ort Low Rate CEM Interface Module
- 1-port OC-48/STM-16 or 4-port OC-12/OC-3 / STM-1/STM-4 + 12-port T1/E1 + 4-port T3/E3 CEM Interface Module
- 1-port OC-192 or 8-port Low Rate CEM 20G Bandwidth Interface Module

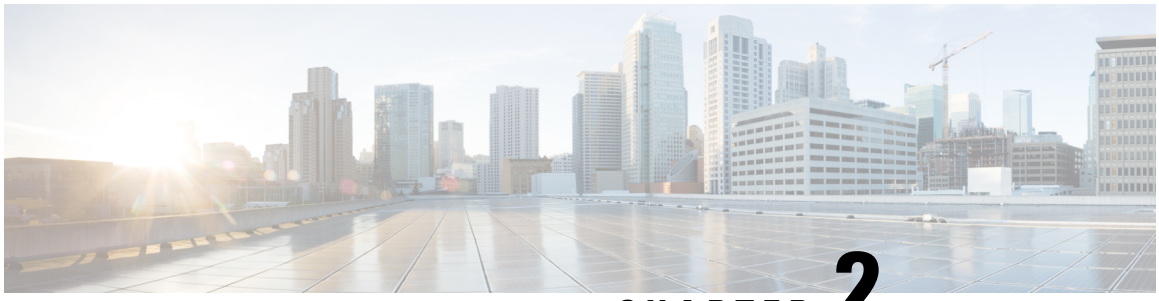
Feature	Description
Cisco IOS XE 17.15.1b	
Invalid Flag attribute in performance monitoring data (PMON)	A new attribute, "Invalid," is introduced in the PMON data in the **show controller** output. The "Invalid" flag associated with Near End and Far End datasets indicates that the dataset is not valid and shouldn't be considered for performance analysis.
Clear Counters command	• Unlike the previous release, where the **clear counters** command reset the old dataset, from this release onwards, the command resets all the PMON datasets, including the current dataset. • You can clear the PMON data for a specific interface module on the device using the **clear controller hw-module** command.
Cisco IOS XE Dublin 17.10.1	
Frame Relay Configuration extended to RSP2 Module	You can configure frame relay on the iMSG serial interface for the following interface modules: • 1-port OC-48/STM-16 or 4-port OC-12/OC-3 / STM-1/STM-4 + 12-port T1/E1 + 4-port T3/E3 CEM interface module

Feature	Description
Multilink Frame Relay (MFR) for IP Interworking	You can configure MFR encapsulation on serial interface for IPv4 and IPv6 interworking for the following interface modules: • 1 port OC-48/STM-16 or 4 port OC-12/OC-3 / STM-1/STM-4 + 12 port T1/E1 + 4 port T3/E3 CEM Interface Module (A900-IMA3G-IMSG) • 1-Port OC-192 or 8-Port Low Rate CEM 20G Bandwidth Interface Module (A900-IMA1Z8S-CXMS) Multiple physical interfaces can be combined into a single bundle, and this frame relay interface supports more bandwidth than that is available from any single physical interface. The ease to add or remove physical interfaces dynamically so that you can modify the total bandwidth available on that interface. The resilience that is provided when multiple physical interfaces are provisioned on a single bundle so that when some of the physical interfaces fail, the bundle continues to support the frame relay service.
QoS on Layer 3-terminated MLPPP Interface	You can configure QoS features such as classification, shaping, queuing, bandwidth, and weighted random early detection on the layer 3-terminated MLPPP interfaces at the egress direction for the following interface modules: • 1 port OC-48/STM-16 or 4 port OC-12/OC-3 / STM-1/STM-4 + 12 port T1/E1 + 4 port T3/E3 CEM Interface Module (A900-IMA3G-IMSG) • 1-Port OC-192 or 8-Port Low Rate CEM 20G Bandwidth Interface Module (A900-IMA1Z8S-CXMS)
Cisco IOS XE Cupertino 17.9.1	
QoS Support on Serial Interfaces	QoS is supported on serial interfaces. You can apply service policies on egress of L3 terminated serial interfaces with both HDLC and PPP encapsulation. By implementing QoS policies on serial interfaces you can shape, classify, or prioritize the data.
MLPPP ACR support for IPv4 or IPv6 Interworking Multiservice Gateway (iMSG)	MLPPP ACR is supported for IPv4 or IPv6 iMSG on: • 1-Port OC-192 or 8-Port Low Rate CEM 20G Bandwidth Interface Module (A900-IMA1Z8S-CXMS) Now, you can increase the bandwidth of a specific OCx port using MLPPP. The restrictions for MLPPP interworking are applicable to iMSG ACR.
Cisco IOS XE Cupertino 17.8.1	

Feature	Description
Frame Relay Support for IP Interworking	Support for frame relay encapsulation on iMSG serial interface for the following interface modules: • 1-port OC-48/STM-16 or 4-port OC-12/OC-3 / STM-1/STM-4 + 12 port T1/E1 + 4-port T3/E3 CEM interface module • 1-port OC-192 or 8-port low rate CEM 20G bandwidth interface module Frame Relay being a streamlined protocol facilitates higher performance and greater efficiency.
Cisco IOS XE Bengaluru 17.5.1	
GR-820-CORE Performance Monitoring	The **`show controller tabular`** command enables you to view the performance monitoring details in tabular form as per GR-820-Core standards.
MLPPP IP Termination on all Serial Physical and Logical Interfaces	This release supports Layer 3 termination using IPv6 addressing on MLPPP interfaces for the 1 port OC-48/STM-16 or 4 port OC-12/OC-3 / STM-1/STM-4 + 12 port T1/E1 + 4 port T3/E3 CEM interface module. In releases earlier, with IPv4 addressing, you can scale up to 512 MLPPP bundles. Now with IPv6 addressing, the MLPPP bundles can be scaled up to 1024.
Unframed Framing Support on E1 and Channel STM links	In this release, a new framing mode unframed is supported for the 1 port OC-48/STM-16 or 4 port OC-12/OC-3 / STM-1/STM-4 + 12 port T1/E1 + 4 port T3/E3 CEM Interface Module. With the unframed mode, you can create serial interfaces under the electrical E1 mode.
Cisco IOS XE Bengaluru 17.4.1	
CEM and IP IW Feature Parity for A900-IMA1Z8S-CXMS and A900-IMA3G-IMSG Interface Modules	• APS and non-APS Support—APS and non-APS support for SDH and SONET for iMSG IPv6 interworking • NxDS0 iMSG IPv4—NxDS0 iMSG IPv4 and NxDS0 APS iMSG IPv4 • UPSR IPv6—UPSR IPv6 • VLANHandoff—IPv4 and IPv6 with VLAN handoff for both cross connect and local connect
DCC Termination	Support for DCC Termination on 1 port OC-48/STM-16 or 4 port OC-12/OC-3 / STM-1/STM-4 + 12 port T1/E1 + 4 port T3/E3 CEM Interface Module. The Data Communication Channel (DCC) feature uses the SONET or SDH Operation Administration and Maintenance (OAM) channel to manage devices that support SONET or SDH interfaces. SONET or SDH standards support extensive operations, administration, management, and provisioning (OAM&P) capabilities.
IPv6 VLAN Handoff Support	VLAN handoff supports IPv4 and IPv6 local connect and cross connect.
Cisco IOS XE Amsterdam 17.3.1	

Feature	Description
ACR and DCR Scale Support	Adaptive Clock Recovery (ACR) and Differential Clock Recovery (DCR) are techniques used for Circuit Emulation (CEM) to recover clocks on the Cisco RSP3 module.
DCC Support	The Data Communication Channel (DCC) feature uses the SONET or SDH Operation Administration and Maintenance (OAM) channel to manage devices that support SONET or SDH interfaces on the Cisco RSP3 module.
Interworking Multiservice Gateway Access Circuit Redundancy (iMSG ACR) support for ASR 900 1-Port OC-192 or 8-Port Low Rate CEM 20G Bandwidth Interface Module (A900-IMA1Z8S-CXMS)	The iMSG ACR feature is supported on serial interfaces for SONET and SDH ACR on the Cisco ASR RSP3 module. DCC and MS features are also supported.
IP Interworking with VLAN Handoff	VLAN handoff enables the support for IP interworking Pseudowire. IP interworking Pseudowire enables the service provider to terminate the TDM circuit early in the network and transport the IP payload on HDLC, PPP, or MLPPP links, over the MPLS core to the Ethernet network.
Interworking Support for nxDS0	Interworking function (IWF) for PPP/HDLC is supported on Ethernet for E1/STM1 ports. This support is extended at nxDS0 level to speed up the GSR TDM migration.
MLPPP ACR support for IPv4 or IPv6 Interworking Multiservice Gateway (iMSG)	MLPPP ACR is supported for IPv4 or IPv6 iMSG on the Cisco ASR RSP3 module. The restrictions for MLPPP interworking are applicable to iMSG ACR.
Cisco IOS XE Amsterdam 17.1.1	
IPv4 Interworking Support for MLPPP Interfaces	The Multilink Point-to-Point (MLPPP) interworking supports IPv4 Layer 2 VPN Interworking with T1 or E1 bundles on the Cisco RSP3 module. The MLPPP interworking enables service providers (offering relatively low-speed links) to use MLP and spread traffic across them in their MPLS networks. The MPLS Multilink PPP feature reduces the number of Interior Gateway Protocol (IGP) adjacencies and facilitates load sharing of traffic.
IPv6 Interworking Support for MLPPP Interfaces	The Multilink Point-to-Point (MLPPP) interworking supports IPv6 Layer 2 VPN Interworking with T1 or E1 bundles on the Cisco RSP3 module. The MLPPP interworking enables service providers (offering relatively low-speed links) to use MLP and spread traffic across them in their MPLS networks. The MPLS Multilink PPP feature reduces the number of Interior Gateway Protocol (IGP) adjacencies and facilitates load sharing of traffic.

Feature	Description
IPv6 Interworking Pseudowire Support on HDLC or PPP Serial Interfaces	The IPv6 interworking is supported for Layer 2 VPN interworking mode. The IPv6 interworking is supported only for HDLC or PPP to Ethernet. Layer 3 termination is supported with serial interfaces with HDLC or PPP encapsulation.
IPv6 Support for Interworking Multiservice Gateway Access Circuit Redundancy	The IPv6 interworking is supported with ACR for Layer 2 VPN.



CHAPTER 2

Preface

This guide provides an overview and explains how to configure various features for the following OCx interface modules:

Table 1: Supported Interface Module

Interface Module	Part Number	Mode
1 port OC-48/STM-16 or 4 port OC-12/OC-3 / STM-1/STM-4 + 12 port T1/E1 + 4 port T3/E3 CEM Interface Module	• A900-IMA3G-IMSG	• T1/E1 • T3/E3
1-Port OC-192 or 8-Port Low Rate CEM Interface Module	• A900-IMA8S1Z-CX	
ASR 900 1-Port OC-192 or 8-Port Low Rate CEM 20G Bandwidth Interface Module	• A900-IMA1Z8S-CXMS	

- Document Organization, on page 7
- Related Documentation, on page 9

Document Organization

Chapter	Description
Overview of the OCx Interface Modules	Provides a high-level overview of OCx CEM interface modules. Also provides additional information such as restrictions, benefits, and so on. Provides information about the Cisco Software License Activation feature.

Chapter	Description
Configuring Synchronous Optical NETwork (SONET) and Synchronous Digital Hierarchy (SDH)	Provides information about how to configure the following features on SONET and SDH: • Line and section configuration parameters such as BERT, clock, loopback, mode, and so on • SONET T1, T3, and VT parameters such as BERT, clock, framing, loopback, shutdown, and so on. • SDH T1, T3, and VC parameters such as BERT, CEM group, clock, loopback, shutdown, and so on. • Loopback remote on T1 and T3 interfaces • CEM group on framed SAToP
Configuring Interworking Multiservice Gateway (iMSG)	Provides information on how to configure the following features: • Serial Interfaces • iMSG Access Circuit Redundancy • Multilink Interfaces • VLAN Handoff
Configuring OCx Protection	Provides information on how to configure the following port and path protection features: • Automatic protection switching (APS) for port protection • Multiplex Section Protection (MSP) for port protection • Unidirectional Path Switching Ring (UPSR) • UPSR over HDLC • Subnetwork Connection Protection (SNCP)
Configuring Data Communication Channel (DCC) and Target Identifier Address Resolution Protocol (TARP)	Provides information on how to configure DCC, Transparent Overhead Tunneling, and TARP.
Configuring Bandwidth for OCx Modules	Provides information on how to configure 5G mode on 1-Port OC-192 or 8-Port Low Rate CEM Interface Module

Chapter	Description
Additional References	Provides information about SONET and SDH frames. • SONET Frame Structure—Details on STS-1 and STS-3 frames , concatenated, and Channelized SONET frames. • SDH Frame Structure—Details on STM-1 frame and Virtual Container (VC).

Related Documentation

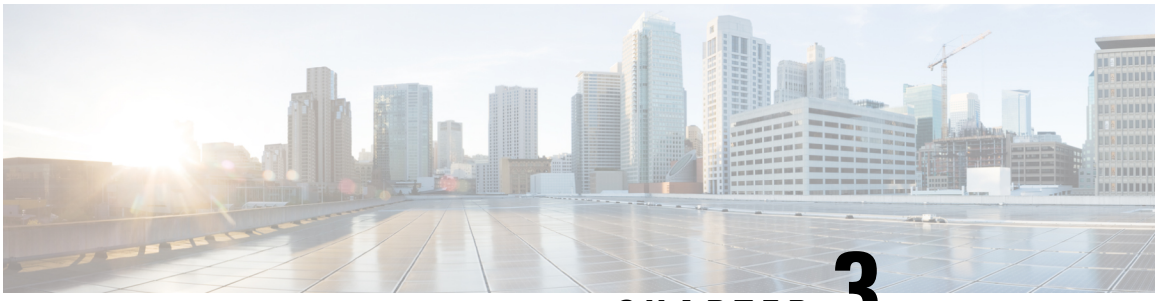
- Alarm Configuring and Monitoring Guide
- CEM Generic Guide
- 48-Port T1 or E1 CEM Interface Module Configuration Guide
- 48-Port T3 or E3 CEM Interface Module Configuration Guide



PART I

Overview of the OCx Interface Module

- **Overview of the OCx Interface Module**, on page 13
- Support for OCx CEM Interface Modules, on page 17
- Port Licensing, on page 27



CHAPTER 3

Overview of the OCx Interface Module

The features of the following OCx interface modules are configured based on the SONET and SDH mode support:

- 1-port OC-48/STM-16 or 4-port OC-12/OC-3 / STM-1/STM-4 + 12-port T1/E1 + 4-port T3/E3 CEM Interface Module (A900-IMA3G-IMSG)
- 1-Port OC-192 or 8-Port Low Rate CEM Interface Module (A900-IMA8S1Z-CX)
- ASR 900 1-Port OC-192 or 8-Port Low Rate CEM 20G Bandwidth Interface Module (A900-IMA1Z8S-CXMS)

SONET Modes

SONET supports the following Circuit Emulation over Packet (CEP), Structure- Agnostic TDM over Packet (SATOP), and Circuit Emulation over Packet-Switched Network (CESoPSN) modes:

CEP Modes

- STS-48C
- STS-12C
- STS-3C
- STS-1
- VT 1.5

SAToP or CESoP

- VT1.5-T1
- T3
- CT3-T1

The following table provides required clock and CEM configuration that is supported on each of the SONET mode:

Table 2: Modes Supported on SONET

	STS-48C	STS-12C	STS-3C	STS-1	VT 1.5	VT 1.5 T1	T3	CT3-T1
Required Configuration								
Mode	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Internal/Line Clock Source	Internal	Internal	Internal	Internal	Internal	Yes	Yes	Yes
ACR/DCR Clock	NA	NA	NA	NA	NA	Yes	Yes	Yes
CEM Configurations								
CEP	Yes	Yes	Yes	Yes	Yes	NA	Yes	NA
SAToP Framed	NA	NA	NA	NA	NA	Yes	Yes	Yes
SAToP Unframed	NA	NA	NA	NA	NA	Yes	Yes	Yes
CESoPSN	NA	NA	NA	NA	NA	Yes	Yes	Yes
Interworking Multiservice Gateway (iMSG) [1]								
iMSG	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Serial Interfaces	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
iMSG ACR	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Multilink Interfaces	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
VLAN Handoff	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
OCx Port Protection								
APS	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
OCx Path Protection								
UPSR	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
UPSR over HDLC	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

[1] Supports Channelized T3/E3or T1/E1

SDH Modes

SDH supports the following modes:

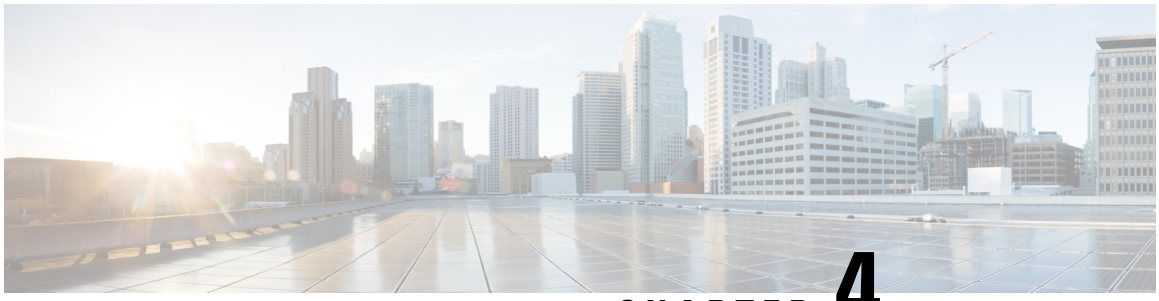
- AU-4-16c (VC4-16c)
- AU-4-4c (VC4-4c)
- AU-4 (VC4)
- AU-4 — TUG-3 — VC-3 — T3 (TUG-3 — T3)
- AU-4 — TUG-3 — VC-3 — E3 (TUG-3 — E3)
- AU-4 — TUG-3 — TUG-2 — VC-11 (TUG-2 — VC-11)
- AU-4 — TUG-3 — TUG-2 — VC-12 (TUG-2 — VC-12)
- AU-4 — TUG-3 — TUG-2 — VC-12 — E1 (TUG-2 — E1)
- AU-3 — VC-3 — T3 (VC-3 — T3)
- AU-3 — TUG-2 — VC-11 — T1 (TUG-2 — T1)
- AU-3 — TUG-2 — VC-11 (TUG-2 — VC-11)
- AU-3 — TUG-2 — VC-12 (TUG-2 — VC-12)
- AU-3 — VC-3 — E3 (VC-3 — T3)

The following table provides required clock and CEM configuration that is supported on each of the SDH mode. The SDH modes provided in brackets are only for the documentation purpose:

Table 3: Modes Supported on SDH

	VC4-16c	VC4-4c	VC4	TUG-2-VC11	TUG-2-VC12	TUG-3-E3	TUG-3-T3	TUG-2-VC11-T1	TUG-2-VC12-E1
Required Configuration									
Mode	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Internal/Line Clock Source	Internal	Internal	Internal	Internal	Internal	Yes	Yes	Yes	Yes
ACR/DCR Clock	NA	NA	NA	NA	NA	Yes	Yes	Yes	Yes
CEM Configurations									
CEP	Yes	Yes	Yes	Yes	Yes	NA	NA	NA	NA
SAToP Framed	NA	NA	NA	NA	NA	Yes	Yes	Yes	Yes

	VC4-16c	VC4-4c	VC4	TUG-2-VC11	TUG-2-VC12	TUG-3-E3	TUG-3-T3	TUG-2-VC11-T1	TUG-2-VC12-E1
SAToP Unframed	NA	NA	NA	NA	NA	Yes	Yes	Yes	Yes
CESoPSN	NA	NA	NA	NA	NA	Yes	Yes	Yes	Yes
Interworking Multiservice Gateway (iMSG)									
iMSG	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Serial Interfaces	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
iMSG ACR	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
OCx Port Protection									
MSP	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
OCx Path Protection									
SNCP	Yes	Yes	Yes	Yes	Yes	NA	NA	NA	NA



CHAPTER 4

Support for OCx CEM Interface Modules

This chapter provides a high-level description and restricions for the following OCx CEM interface modules:

- 1 port OC-48/STM-16 or 4 port OC-12/OC-3 / STM-1/STM-4 + 12 port T1/E1 + 4 port T3/E3 CEM Interface Module (A900-IMA3G-IMSG)
- 1-Port OC-192 or 8-Port Low Rate CEM Interface Module (A900-IMA8S1Z-CX)
- ASR 900 1-Port OC-192 or 8-Port Low Rate CEM 20G Bandwidth Interface Module (A900-IMA1Z8S-CXMS)

- Configuring Support of 1 port OC-48/STM-16 or 4 port OC-12/OC-3 / STM-1/STM-4 + 12 port T1/E1 + 4 port T3/E3 CEM Interface Module, on page 17
- Configuring Support of 1-Port OC-192 or 8-Port Low Rate CEM Interface Module, on page 18
- Configuring Support for ASR 900 1-Port OC-192 or 8-Port Low Rate CEM 20G Bandwidth Interface Module (A900-IMA1Z8S-CXMS) , on page 18
- Features supported on OCx CEM Interface Module, on page 22
- Restrictions for Configuring OCx CEM Interface Modules, on page 25

Configuring Support of 1 port OC-48/STM-16 or 4 port OC-12/OC-3 / STM-1/STM-4 + 12 port T1/E1 + 4 port T3/E3 CEM Interface Module

The 1 port OC-48/STM-16 or 4 port OC-12/OC-3 / STM-1/STM-4 + 12 port T1/E1 + 4 port T3/E3 CEM Interface Module has 12XDS1, 4XDS3, electrical interfaces, and 4XSFP ports that can provide multiple functions such as 1XOC-48/12/3 and 3XOC-12/3. The maximum speed supported on OCx ports is OC-48. The interface module supports a maximum of 3G CEM traffic.

Note In addition to support on RSP2 module, the IM is supported on RSP3 from the Cisco IOS XE 16.9.x release.

Configuring Support of 1-Port OC-192 or 8-Port Low Rate CEM Interface Module

The OC-192 interface module with 8-port low rate CEM interface module delivers one active port of OC192 or STM-64 connectivity, or up to eight ports of OC3/12 or STM-1/-4 or up to 4 ports of OC48 or STM-16 connectivity on the router with RSP3. The module can be clocked from a line or from an internal clock source. This module delivers true high density, multiservice and multi-rate capabilities in a small form factor. The interface module can be software configured as either Synchronous Optical Networking (SONET) mode or Synchronous Digital Hierarchy (SDH) mode per module in the ASR 900 Series configuration.

Configuring Support for ASR 900 1-Port OC-192 or 8-Port Low Rate CEM 20G Bandwidth Interface Module (A900-IMA1Z8S-CXMS)

The ASR 900 1-Port OC-192 or 8-Port Low Rate CEM 20G Bandwidth Interface Module (A900-IMA1Z8S-CXMS) is supported on the RSP3 module and has the capability for SONET or SDH termination with SAToP, CESoP, and CEP traffic types.

Note The Ethernet and Multiservice Gateway features are not supported on this IM for the Cisco IOS XE 16.12.1 Release.

The IM is capable of processing a maximum of 20G with different types of traffic such as 10G CEM, 2.5G iMSG, 2.5G Ethernet, and 6.9Mbps DCC. However for the Cisco IOS XE Release 16.12.1, only the 10G CEM traffic is supported. In the 10G mode, 7.5G CEM traffic is supported.

In this IM, all the eight 1G ports can be configured as OC-48 and you can utilize a maximum of 192 STS-1.

The ASR 9001-port OC-192 or 8-port Low Rate CEM 20G Bandwidth interface module functions similar to the 1-port OC-192/STM-64 or 8-port OC-3/12/48/STM-1/-4/-16 interface module. The configurations remain the same.

The following TDM features are supported:

- SNMP
- Local, network, or remote loopback
- BERT (both system and line). The system side BERT is not supported in the framed SAToP mode.
- OH config
- Network synchronization
- SSM
- Shut at port and CEM-group level
- DCC is supported starting from Cisco IOS XE Amsterdam 17.3.1 release

- Interworking Multiservice Gateway Access Circuit Redundancy (iMSG ACR) support starting with the Cisco IOS XE 17.3.1 release.

The following TDM features are supported starting from Cisco IOS XE Bengaluru 17.4.1 release:

- APS and non-APS for SDH and SONET for iMSG IPv6 interworking.
- NxDS0 iMSG IPv4 and NxDS0 APS iMSG IPv4.
- UPSR IPv6.
- IPv4 with VLAN handoff for cross connect and local connect.

The CEM features such as SAToP, CESoP, and CEP are supported in the following modes:

- Unprotected CEM with ACR or DCR are supported in the following modes:
  - T1, T3, E1, E3, DS0, DS1, and DS3
  - CEM Payload size configurable.

  APS CEM with ACR or DCR are supported in the following modes
  - DS0, DS1, DS3, T1, T3, E1, E3, AU-3, and AU-4
  - CEM payload size configurable.
- UPSR at VT or STS mode.
- DS1 (with VT Protection) or DS3 (STS Protection) with ACR or DCR
- CEM Class with configurable payload size or jitter buffer

Modes of Operation

The interface module operates in following two modes:

- Single XFI or 10 G mode
- Dual XFI or 20 G mode

Single XFI or 10 G mode

Consider the following requirement while working on the 10 G mode:

- OC-192 or SFP+ port is supported on the 10G GE port. In the 10G mode, 7.5G for CEM traffic is supported.
- If bandwidth is available to accommodate a particular circuit or Ethernet port, then configuration is allowed, and it can be performed. Otherwise, the configuration is rejected due to bandwidth limitation.
- When there is a change in the payload size, the required bandwidth gets modified accordingly. This in turn checks for the bandwidth and if the sufficient bandwidth is not available, the configuration is rejected.
- You can remove or delete the existing configuration from the port and perform new configuration on the port.

Dual XFI or 20 G mode

You can convert the IM into dual mode. In 20G mode of operation, channelized (xfi0) and non-channelized (xfi1) bandwidth are available.

Enter the following commands to convert into dual mode and then reload the IM:

```
router (config)# platform hw-module configuration
PE1(conf-plat-hw-conf)# hw-module <slot/subslot> A900-IMA1Z8S-CXMS mode 10G_CEM
```

Consider the following requirements while working on the 20-G mode:

- For configuring CEM group, the software performs bandwidth check. If the required bandwidth is not available, you cannot configure the CEM group.
- If a maximum capacity configuration is already performed on the IM and you update the payload size, then the update is not accepted on the same channel (xfi). You need to remove some configurations on circuits and then update the payload again.

For slot compatibility, refer Supported RSP and Slots in the Cisco ASR 900 Series Routers and Cisco Interface Module Hardware Installation Guide.

Restrictions and Limitations for ASR 900 1-Port OC-192 or 8-Port Low Rate CEM 20G Bandwidth Interface Module (A900-IMA1Z8S-CXMS)

Feature Restrictions

The following features are not supported:

- Ethernet
- EOS L1 or L2
- MS features are not supported for the Cisco IOS XE 16.12.1 release. Starting with the Cisco IOS XE Amsterdam 17.3.1 release, MS features are supported.
- DCC is **not** supported until the Cisco IOS XE 16.12.1 release.
- IPv4 or IPv6 iMSG is not supported for the Cisco IOS XE 16.12.1 release.

  Starting with the Cisco IOS XE Amsterdam 17.3.1 release, IPv4 iMSG is supported.

  Starting with the Cisco IOS XE Bengaluru 17.4.1 release, IPv6 iMSG is supported.

  For iMSG IPv6 MTU, the change in configuring MTU value is not supported. Ensure that you configure the circuit with the default MTU value.
- MLPPP for serial interface is not supported for the Cisco IOS XE Amsterdam 17.3.1 release.
- STS-192c or VC-4-64c concatenation
- Low-order path concatenation (VCAT)
- Fractional CEP
- BLSR for SONET or MSSP ring for SDH
- SyncE and PTP Support on EoS (L1 or L2/L3 Terminated)
- Card level protection

- Nonstandard concatenation such as STS-6c, STS-9c, STS-15c, STS-18c, and so on
- APS or MSP 1:N, where N is greater than 1.
- TSOP support
- Auto detection support
- SONET to SDH and SDH to SONET Translation
- CAS Signaling
- HSPW
- Scrambling is not supported in the POS mode.
- In A900-IMA1Z8S-CXMS, invalid FE flag gets asserted for the current interval when the controller is shut and no shut.

Management Restrictions

The following are some management restrictions to consider while configuring the module:

- The ports can be configured and used regardless of available backplane bandwidth or HO Path resources.
- Provisioning a new CEM circuit and payload size change to the new CEM circuit is allowed as long as bandwidth is available.
- Gigabit Ethernet configuration is allowed if required bandwidth is available. Bandwidth reallocation can be performed based on some following scenarios:
  - The required bandwidth is not available on channelized xfi, but sufficient bandwidth is available on nonchannelized xfi. In such cases, you should remove some configuration from circuits on the channelized xfi and then provision Gigabit Ethernet followed by CEM circuit provision.

Scale Restrictions

- The maximum number of supported VT1.5 CESoP circuits are 672 per interface module for Cisco IOS XE 16.12.x release.
- For the Cisco IOS XE Amsterdam 17.3.1 release, a maximum of 1000 serial interfaces can be configured on RSP2 module as 1000 internal VLANs are reserved for serial interfaces. The same scale limit is applicable for RSP3 module.
- For the Cisco IOS XE Amsterdam 17.3.1 release, CEM FPGA supports up to 1016 data channels per interface module.
- For the Cisco IOS XE Amsterdam 17.3.x release, a maximum of **5376** ACR and DCR session scale is supported on the Cisco 1-port OC-192 Interface module or 8-port Low Rate Interface Module (ASR 900 Combo 8-port SFP GE and 1-port 10GE IM with CEM, 10G). For releases before the Cisco IOS XE Amsterdam 17.3.1 release, only 2000 session are supported.

Table 4: Dual-Mode Restrictions for Gigabit Ethernet port

Circuit Type	Scale Supported
DS1 SAToP	2800

Circuit Type	Scale Supported
VT 1.5 CEP Pseudowire	2800
Gigabit Ethernet	1 x 10 G and 8 x 1 G
ACR or DCR	2000 per interface module
DS1 CESoP Pseudowire	672 per interface module

Features supported on OCx CEM Interface Module

Table 5: Features supported on OCx CEM Interface Module on ASR 900 Series Routers

Feature	OCx CEM Interface Module
Port Licensing	Supported only on the ASR 900 series platform. • 1-port OC-48/STM-16 or 4-port OC-12/OC-3 / STM-1/STM-4 + 12-port T1/E1 + 4-port T3/E3 module • 1-port OC-192 or 8-port low rate module • ASR 900 1-port OC-192 or 8-port low rate CEM 20G bandwidth module
SONET	• 1-port OC-48/STM-16 or 4-port OC-12/OC-3 / STM-1/STM-4 + 12-port T1/E1 + 4-port T3/E3 module • 1-port OC-192 or 8-port low rate module • ASR 900 1-port OC-192 or 8-port low rate CEM 20G bandwidth module
SDH	• 1-port OC-48/STM-16 or 4-port OC-12/OC-3 / STM-1/STM-4 + 12-port T1/E1 + 4-port T3/E3 module • 1-port OC-192 or 8-port low rate module • ASR 900 1-port OC-192 or 8-port low rate CEM 20G bandwidth module
CEM Features	

Feature	OCx CEM Interface Module
Automatic Protection Switching	• 1-port OC-48/STM-16 or 4-port OC-12/OC-3 / STM-1/STM-4 + 12-port T1/E1 + 4-port T3/E3 module • 1-port OC-192 or 8-port low rate module • ASR 900 1-port OC-192 or 8-port low rate CEM 20G bandwidth module
Multiplex Section Protection	• 1-port OC-48/STM-16 or 4-port OC-12/OC-3 / STM-1/STM-4 + 12-port T1/E1 + 4-port T3/E3 module • 1-port OC-192 or 8-port low rate module • ASR 900 1-port OC-192 or 8-port low rate CEM 20G bandwidth module
Unidirectional Path Switching Ring Path Protection	• 1-port OC-48/STM-16 or 4-port OC-12/OC-3 / STM-1/STM-4 + 12-port T1/E1 + 4-port T3/E3 module • 1-port OC-192 or 8-port low rate module • ASR 900 1-port OC-192 or 8-port low rate CEM 20G bandwidth module
UPSR Over HDLC	• 1-port OC-48/STM-16 or 4-port OC-12/OC-3 / STM-1/STM-4 + 12-port T1/E1 + 4-port T3/E3 module • 1-port OC-192 or 8-port low rate module • ASR 900 1-port OC-192 or 8-port low rate CEM 20G bandwidth module
Subnetwork Connection Protection	• 1-port OC-48/STM-16 or 4-port OC-12/OC-3 / STM-1/STM-4 + 12-port T1/E1 + 4-port T3/E3 module • 1-port OC-192 or 8-port low rate module • ASR 900 1-port OC-192 or 8-port low rate CEM 20G bandwidth module

Feature	OCx CEM Interface Module
Data Communication Channel	• 1-port OC-48/STM-16 or 4-port OC-12/OC-3 / STM-1/STM-4 + 12-port T1/E1 + 4-port T3/E3 module • 1-port OC-192 or 8-port low rate module • ASR 900 1-port OC-192 or 8-port low rate CEM 20G bandwidth module
Transparent Overhead Tunneling Data Communication Channel	• 1-port OC-48/STM-16 or 4-port OC-12/OC-3 / STM-1/STM-4 + 12-port T1/E1 + 4-port T3/E3 module • 1-port OC-192 or 8-port low rate module • ASR 900 1-port OC-192 or 8-port low rate CEM 20G bandwidth module
Target Identifier Address Resolution Protocol	• 1-port OC-48/STM-16 or 4-port OC-12/OC-3 / STM-1/STM-4 + 12-port T1/E1 + 4-port T3/E3 module • 1-port OC-192 or 8-port low rate module • ASR 900 1-port OC-192 or 8-port low rate CEM 20G bandwidth module
5G Mode	• 1-port OC-192 or 8-port low rate module
iMSG Features	
Serial Interfaces	• 1-port OC-48/STM-16 or 4-port OC-12/OC-3/STM-1/STM-4 + 12-port T1/E1 + 4-port T3/E3 module • ASR 900 1-port OC-192 or 8-port low rate CEM 20G bandwidth module
iMSG ACR	• 1-port OC-48/STM-16 or 4-port OC-12/OC-3/STM-1/STM-4 + 12-port T1/E1 + 4-port T3/E3 module • ASR 900 1-port OC-192 or 8-port low rate CEM 20G bandwidth module
Multilink Interfaces	• 1-port OC-48/STM-16 or 4-port OC-12/OC-3/STM-1/STM-4 + 12-port T1/E1 + 4-port T3/E3 CEM IM module

Feature	OCx CEM Interface Module
VLAN Handoff	• 1-port OC-48/STM-16 or 4-port OC-12/OC-3/STM-1/STM-4 + 12-port T1/E1 + 4-port T3/E3 module • ASR 900 1-port OC-192 or 8-port low rate CEM 20G bandwidth module

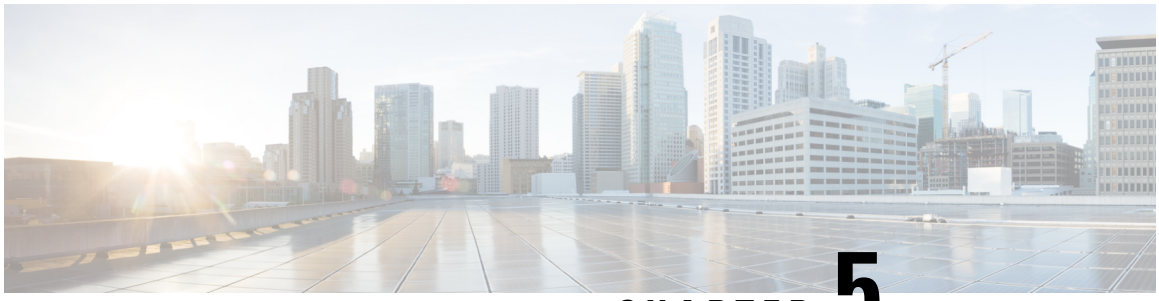
For more information on the features supported with release versions, see Cisco ASR 900 Series Aggregation Services Routers Feature Optics Matrix.

Restrictions for Configuring OCx CEM Interface Modules

- Mixed mode support, for example, T1 and E1 or T3 and E3 or SONET and SDH simultaneously on different ports is not available.
- E1 or E3, Unidirectional Path Switching Ring (UPSR), and Data Communication Channel (DCC) are not supported.
- Multiservice functionality: MLPPP, FR, and MLFR are not supported.

  Starting with Cisco IOS XE Amsterdam 17.1.x, MLPPP is supported.
- EoS and EoPDH are not supported.
- The **configure replace** command is *not* supported.
- On RSP3 module, the CEM OCx IM is not supported in slots 0 and 1.

  On the Cisco ASR907 router, the CEM OCx IM is not supported in the default license mode but the IM is supported in the service-offload license mode.
- Synchronization Status Message (SSM) is not supported on T3 ports for 48-port T3 and E3 CEM IM and 1-port OC-48/STM-16 or 4-port OC-12/OC-3/STM-1/STM-4 + 12-port T1/E1 + 4-port T3/E3 CEM IM.



CHAPTER 5

Port Licensing

The Cisco Software License Activation feature is a set of processes and components to activate Cisco IOS-XE software feature sets by obtaining and validating fee-based Cisco software licenses.You should enable the license *only* for OCx ports. License is not required for the ports 0-15 (DSx ports).

You should associate a required license to a port. Many licenses can be configured for a port. Only one license can be associated with a port as only one rate can be configured at a time. Other licenses are not required unless rate is changed frequently.

No license is enabled on the port by default. Same port license (OC-3 or OC-12) can be used for Legacy OC-3 IM. A port can be enabled with any one of the following license types:

- OC-3
- OC-12
- OC-48

On each IM, OCx port can be configured on ports 16-19. For example, a maximum of four OC-3 ports can be configured on ports 16-19. A maximum of four OC-12 ports can be configured on ports 16-19. A maximum of one OC-48 port can be configured on ports 16-19.

- Information About Port Licensing, on page 27
- Installing a License, on page 28
- Enabling a License, on page 28
- Disabling a License, on page 29
- Uninstalling a License, on page 29

Information About Port Licensing

Scenario of IM Removal

- All licenses enabled on the IM ports are removed.
- The free licenses can be associated with the same or different IM ports.

Scenario of IM Re-insertion

- When IM is inserted back in the same slot, the IM ports require the licenses based on the configurations.
- The available free licenses are used and old configurations are retained.

- When free licenses are not available, the controller port moves to "shut" state and the following error message is displayed:

```
configure terminal
controller mediatype 0/1/19
mode sonet
rate oc3
controller sonet 0/1/19
rate oc3
 license is not enabled for this rate
% Unable to configure this rate.
end
```

- To remove the "shut" state, perform any one of the following actions:
  - Remove all the configurations present at rate level and beyond.
  - Enable the license on the port that has the same rate as that of the configured controller. For example, enable OC3 license for any OC3 configuration to remove the "shut" state.

  Thus, port configurations remain intact and controller port re-configuration is not required.

Installing a License

To install or upgrade a license by using the **license install** command, you must have already received the license file from the Cisco Product License Registration portal at http: www.cisco.com go license (or you already backed up the license by using the **license save** command).

To install the license:

```
enable
 show license udi
Convert the PAK to a license by entering the PAK and the UDI into the Cisco Product License
 Registration portal: http:  www.cisco.com go license
license install stored-location-url
show license detail
end
```

Enabling a License

Use the **platform enable controller Mediatype** <*slot/bay/port*> <*port rate*> to enable a particular license type on the controller port. Providing a particular license type is mandatory to enable the license on the IM.

Note This command is not applicable for DSx ports (0-15).

Note You should configure controller mediatype and controller SONET before enabling the license on the port. License enabling is allowed when the license with the same rate is configured on the port. The configuration fails if the license with a different rate is configured on the port.

To enable port licensing:

```
enable
configure terminal
platform enable controller MediaType 0/4/16 oc3
controller MediaType 0/4/16
mode sonet
exit
controller sonet 0/4/16
rate oc3
exit
```

Verifying License Configuration

Use the **show license detail** command to verify the license configuration:

```
Router#show license detail
Index: 15 Feature: oc3  Version: 1.0
        License Type: Permanent
        License State: Active, In Use
        License Count: 1/1/0  (Active/In-use/Violation)
        License Priority: Medium
        Store Index: 4
        Store Name: Primary License Storage
#
```

Disabling a License

Use the **no platform enable controller Mediatype** <*slot/bay/port*> <*port rate*> to disable a particular license type on the controller port.

Note Disabling a license is not successful if a rate is configured on the controller that requires the license. Hence, you should first remove the controller configuration before disabling the license.

To disable port licensing:

```
enable
configure terminal
controller sonet 0/4/16
sts-1 1
no vtg 1 t1 1 cem-group 23 unframed
no mode vt-15
controller MediaType 0/4/16
no mode sonet
exit
no platform enable controller MediaType 0/4/16 oc3
```

Uninstalling a License

To uninstall a license:

```
enable
configure terminal
```

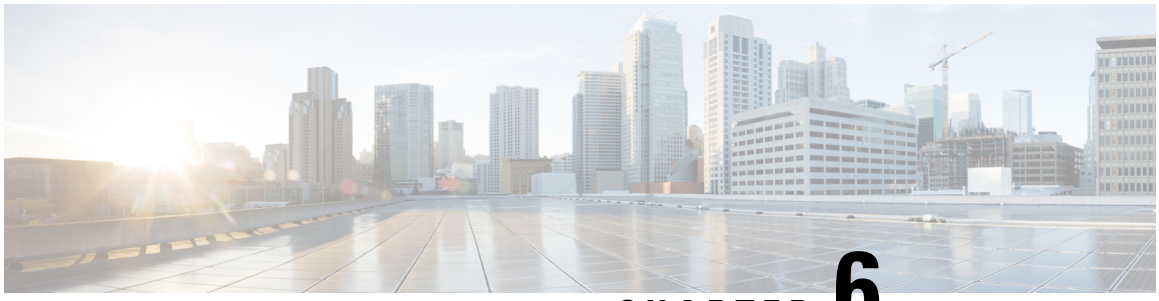
```
no platform enable controller MediaType slot/bay/port OC3
end
license clear feature-name
```



PART II

SONET and SDH

- Configuring SONET, on page 33
- Configuring SDH, on page 81



CHAPTER 6

Configuring SONET

This module describes how to configure Synchronous Optical NETwork (SONET). SONET defines optical signals and a synchronous frame structure for multiplexed digital traffic. SONET equipment is generally used in North America.

The transport network using SONET provides much more powerful networking capabilities than existing asynchronous systems.

- Overview of SONET, on page 33
- Restrictions for SONET, on page 34
- SONET path BER threshold configuration guidelines, on page 35
- SONET Switching , on page 36
- SONET Hierarchy, on page 37
- SONET Line and Section Configuration Parameters, on page 38
- SONET Path Level Configuration Parameters, on page 38
- SONET T1 Configuration Parameters, on page 39
- SONET T3 Configuration Parameters, on page 39
- SONET VT Configuration Parameters, on page 39
- How to Configure SONET, on page 40
- Configuring Port Rate and Verifying Pluggables, on page 71
- Loopback Remote on T1 and T3 Interfaces, on page 74
- Configuring POS Scrambling, on page 76
- Associated Commands, on page 77

Overview of SONET

SONET is a set of standards that define the rates and formats for optical networks specified in GR–253–CORE. SONET is based on a structure that has a basic frame format and speed. The frame format used by SONET is the Synchronous Transport Signal (STS), with STS-1 as the base-level signal at 51.84 Mbps. An STS-1 frame can be carried in an OC-1 signal.

SONET has a hierarchy of signaling speeds.

Restrictions for SONET

- With Synchronous Transport Signal (STS) Circuit Emulation over Packet (CEP) or STS concatenated CEP mode, if you receive a B3 error, then the Remote Error Indication (REI) won't be generated. Request for Comments (RFC) reference—RFC 4842.
- Prior to Cisco IOS XE Cupertino 17.9.1 release, in V-15 or VC1x mode without or with CEM (SAToP/CEP/CESoP), overhead TX_V5 default value is 1.
- From Cisco IOS XE Cupertino 17.9.1 release onwards, when CEM (SAToP (framed or Unframed) and CESoP) is configured for VT-15 or VC1x mode, overhead TX_V5 default value is 2. If CEM isn't configured or VT CEP is configured, then the default value for V5 Overhead is 1. V5 byte value can be modified according to need using configuration *vt <> vt <> overhead v5 <>*.
- Rate combinations are one port of OC-48 or four ports of OC-12 or OC-3.
- Only 16 BERT Patterns can be configured at a time.
- VT1.5 VT can't be configured if VT1.5 T1/DS1 is configured with the same KLM value.
- PMON fields aren't supported for VT1.5 VT and DS3 or T3.
- PMON Far-end parameters aren't supported.

Restrictions on Bandwidth

- Total available bandwidth is 10G.

  The following configuration is blocked and an error message is displayed after the maximum bandwidth is utilized:

  ```
  rate OC3| OC12| OC48| OC192
  ```

  The bandwidth of adjacent ports shouldn't exceed OC-48.

  The following table shows the bandwidth used by different rates:

  Table 6: Bandwidth Used by Different Rates

Rate	Bandwidth
OC-3	155.52 Mbps
OC-12	622.08 Mbps
OC-48	2.4 Gbps

Restrictions for Clock Source Configuration

- Only four ports can be configured in SONET line for clock source configuration per chassis.
- You should configure the clock source line and network-clock sync together to receive the clock from a remote port that is connected to the SONET port.

Restrictions for BER Threshold

- The BER threshold value 10e-9 is not supported for the following line, path, and VT BER CLIs on the following interface modules:
  - Line BER CLIs **threshold b2-tca**, **threshold sd-ber** and **threshold sf-ber**.
  - PATH BER CLIs **threshold b3-ber_sd**, **threshold b3-ber_sf**, and **threshold b3-tca**.
  - VT BER CLIs **threshold bip2-sd**, **threshold bip2-sf**, and **threshold bip2-tca**.
  - **Not Supported Interface Modules for the Above BER CLIs**
    - A900-IMA48T-C
    - A900-IMA3G-IMSG
    - A900-IMA1Z8S-CXMS
    - A900-IMA1Z8S-CX

Restrictions for T1 CESoPSN service

- The loop network payload is not supported with CEM provisioned. However, with CESoP, the network payload is looped back.
- In T1 IM, payload loopback is supported with CESoP.
- In SONET IMs and 48xT3/E3 IM, network payload loopback is not supported.

SONET path BER threshold configuration guidelines

Prior to IOS XE version 17.15.4, the B3 Signal Failure (SF), Signal Degrade (SD), and Threshold Crossing Alarm (TCA) alarms were triggered simultaneously whenever the relevant thresholds were met. Starting with IOS XE 17.15.4, this behavior was refined to improve alarm clarity and troubleshooting efficiency.

Now, when the Bit Error Rate (BER) falls within the 3 to 5 range, the system asserts the SF alarm first. The SD alarm will only be triggered if the SF alarm is not already active, ensuring that SF takes priority over SD when both conditions are present. The behavior of the TCA alarm remains unchanged. This change improves the alarm assertion sequence by more accurately representing the hierarchy of signal conditions, making alarm reporting clearer and simplifying the troubleshooting process.

Find the path BER threshold configuration for SONET.

Table 7: Path BER threshold configuration for SONET

Path BER Configuration	Prior to IOS XE 17.15.4	Starting with IOS XE 17.15.4
B3 SF	3 to 8	3 to 5
B3 SD	3 to 8	5 to 8
B3 TCA	3 to 8	3 to 8

SONET Switching

SONET Switching is achieved on optical interface modules by circuit emulation. Circuit Emulation (CEM) is a way to carry TDM circuits over packet switched network. CEM embeds TDM bits into packets, encapsulates them into an appropriate header and then sends that through Packet Switched Network (PSN). The receiver side of CEM restores the TDM bit stream from packets.

Modes of CEM:

- **Structure Agnostic TDM over Packet (SAToP)** (RFC 4553) – Structure-Agnostic TDM over Packet (SAToP) mode is used to encapsulate T1 or T3 unstructured (unchannelized) services over packet switched networks. In SAToP mode, the bytes are sent out as they arrive on the TDM line. Bytes do not have to be aligned with any framing.

  In this mode, the interface is considered as a continuous framed bit stream. The packetization of the stream is done according to IETF RFC 4553. All signaling is carried transparently as a part of a bit stream.

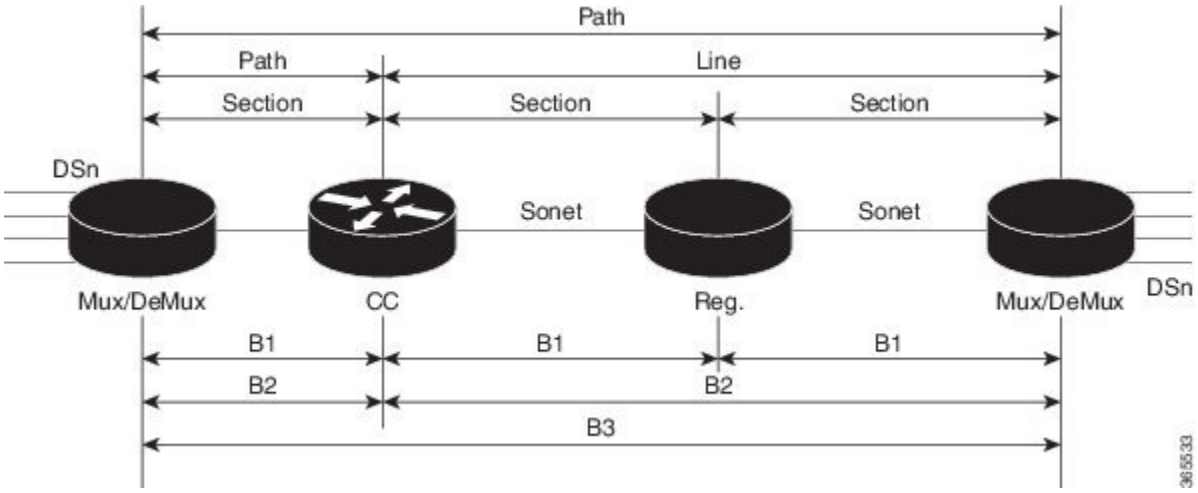
- **Circuit Emulation Service over Packet (CEP)** (RFC 4842) - CEP mode is used to encapsulate SONET payload envelopes (SPEs) like VT1.5 or VT2 or STS-1 or STS-Nc over packet switched networks. In this mode, the bytes from the corresponding SPE are sent out as they arrive on the TDM line. The interface is considered as a continuous framed bit stream. The packetization of the stream is done according to IETF RFC 4842.

Table 8: Modes of CEM

Mode	CEM	Ports
STS-48C	CEP	OC-48, OC-192
STS-12C	CEP	OC-12, OC-48, OC-192
STS-3C	CEP	OC-3, OC-12, OC-48, OC-192
STS-1	CEP	OC-3, OC-12, OC-48, OC-192
DS3	SAToP	OC-3, OC-12, OC-48, OC-192
DS3-T1	SAToP	OC-3, OC-12, OC-48, OC-192
VT 1.5	CEP	OC-3, OC-12, OC-48, OC-192
VT DS1	SAToP	OC-3, OC-12, OC-48, OC-192

SONET Hierarchy

Figure 1: A SONET Link



Each level of the SONET hierarchy terminates its corresponding fields in the SONET payload, as follows:

Section

A section is a single fiber run that can be terminated by a network element (Line or Path) or an optical regenerator.

The main function of the section layer is to properly format the SONET frames, and to convert the electrical signals to optical signals. Section Terminating Equipment (STE) can originate, access, modify, or terminate the section header overhead.

Line

Line-Terminating Equipment (LTE) originates or terminates one or more sections of a line signal. The LTE does the synchronization and multiplexing of information on SONET frames. Multiple lower-level SONET signals can be mixed together to form higher-level SONET signals. An Add/Drop Multiplexer (ADM) is an example of LTE.

Path

Path-Terminating Equipment (PTE) interfaces non-SONET equipment to the SONET network. At this layer, the payload is mapped and demapped into the SONET frame. For example, an STS PTE can assemble 25 1.544 Mbps DS1 signals and insert path overhead to form an STS-1 signal.

This layer is concerned with end-to-end transport of data.

SONET Line and Section Configuration Parameters

The following parameters affect SONET configuration at the line and section levels:

- **Overhead** — Sets the SONET overhead bytes in the frame header to a specific standards requirement, or to ensure interoperability with equipment from another vendors.
  - **J0** — Sets the J0 or C1 byte value in the SONET section overhead.

Note 1 byte, 16 bytes, and 64 bytes are the supported values for J0.

  - **S1S0** — Sets the SS bits value of the H1 byte in the SONET line overhead.
- **Loopback** — Sets a loopback to test the SONET port.
- **AIS-Shut** — Configures the SONET port to send the Alarm Indication Signal (AIS) at shutdown.
- **Shut** — Disables an interface.
- **Alarm Reporting** — Enables reporting for all or selected alarms.
  - **lias** —Enables line alarm indication signal.
  - **lrdi** — Enables line remote defect indication signal.
  - **pais** — Enables path alarm indication signal.
  - **plop** — Enables loss of pointer failure signal for a path.
  - **pplm** — Enables path payload mismatch indication.
  - **prdi** — Enables path remote defect indication signal.
  - **sd-ber** — Sets Signal Degrade BER threshold.
- **Clock** — Specifies the clock source, where:
  - **line** —The link uses the recovered clock from the line.
  - **internal** — The link uses the internal clock source. This is the default setting.

SONET Path Level Configuration Parameters

The following parameters affect SONET configuration at the path level:

- **BERT** — Starts the BERT test.
- **Clock** — Specifies the clock source for a path.
- **Exit** — Exits from SONET path configuration mode.
- **Loopback** — Sets the entire path in the loopback mode.

- **Mode** — Specifies the path operation mode.
- **No** — Negates a command or sets its defaults.
- **Overhead** — Configures SONET path overhead flags.
- **Shutdown** — Disables the SONET path.
- **Threshold** — Sets the path BER threshold values.
- **vtg** — Sets the VT-15 configuration.

SONET T1 Configuration Parameters

The following parameters affect SONET T1 configuration:

- **BERT** — Starts the BERT test.
- **Clock** — Specifies the clock source for T1 interface.
- **Description** — Specifies the description of the controller.
- **Framing** — Specifies the type of a framing on T1 interface.
- **Loopback** — Sets the T1 interface in the loopback mode.
- **Shutdown** — Disables the T1 interface.

SONET T3 Configuration Parameters

The following parameters affect SONET T3 configuration:

- **Clock** — Specifies the clock source for T3 link.
- **Description** — Specifies the description of the controller.
- **Framing** — Specifies the type of a framing on T3 interface.
- **Loopback** — Sets the T3 link in the loopback mode.
- **Shutdown** — Disables the T3 interface.

SONET VT Configuration Parameters

The following parameters affect SONET VT configuration:

- **BERT** — Starts the BERT test.

  CEM Group — Specifies the time slots for CEM group mapping.
- **Clock** — Specifies the clock source for VT.
- **Description** — Specifies the description of the controller.

- **Loopback** — Sets the VT in the loopback mode.
- **Overhead** — Configures VT line path overhead flags.
- **Shutdown** — Disables the VT interface.
- **Threshold** — Configures the VT threshold values.

How to Configure SONET

This section describes how to configure SONET.

Each SFP port (0-7) can be configured as OC-3, OC-12, OC-48, or Gigabit Ethernet. SFP+ port (8) can be configured as OC-192 or 10 Gigabit Ethernet.

Prerequisites for Configuring SONET

You must select the MediaType controller to configure and enter the controller configuration mode.

You must configure the controller as a SONET port.

Configuring MediaType Controller

To configure MediaType Controller, use the following commands:

```
enable
configure terminal
controller MediaType 0/0/16
mode sonet
end
```

Configuring SONET Ports

To configure SONET ports, use the following commands:

```
enable
configure terminal
controller MediaType 0/0/16
mode sonet
controller sonet 0/0/16
rate OC12
end
```

The above example shows how to configure SONET ports in OC-12 mode.

Managing and Monitoring SONET Line

This section describes how to manage and monitor SONET.

Configuring Line and Section Overhead

To configure line and section overhead, use the following commands:

```
enable
configure terminal
controller MediaType 0/0/16
mode sonet
controller sonet 0/0/16
overhead s1s0 2
overhead j0 tx length 1-byte
end
```

Note To restore the system to its default condition, use the **no** form of the command.

Configuring Line Loopback

To configure loopback, use the following commands:

```
enable
configure terminal
controller sonet 0/0/16
loopback local
end
```

Note To restore the system to its default condition, use the **no** form of the command.

Configuring AIS Shut

To configure AIS-Shut, use the following commands:

```
enable
configure terminal
controller sonet 0/0/16
ais-shut
end
```

Note The **no ais-shut** command will not send AIS.

Configuring Shut

To configure Shut, use the following commands:

```
enable
configure terminal
controller sonet 0/0/16
shutdown
end
```

Note Use the **no shutdown** command to disable the interface.

Configuring Alarm Reporting

To configure alarm reporting, use the following commands:

```
enable
configure terminal
controller sonet 0/0/16
alarm-report b2-tcs
end
```

Note To restore the system to its default condition, use the **no** form of the command.

Configuring Clock

To configure clock, use the following commands:

```
enable
configure terminal
controller MediaType 0/0/16
mode sonet
controller sonet 0/0/16
clock source line
end
```

Note The default mode is internal.

Note To restore the system to its default condition, use the **no** form of the command.

Configuring Network-Clock SONET

To configure network-clock SONET, use the following commands:

```
enable
configure terminal
network-clock input-source 1 controller sonet 0/0/16
end
```

Configuring STS-1 Modes

To configure STS-1 modes, use the following commands:

```
enable
configure terminal
controller sonet 0/0/16
sts-1 1
mode vt-15
end
```

Note There is no default mode. The following modes are supported:

- mode vt-15
- mode ct3
- mode t3
- mode unframed

Note To restore the system to its default condition, use the **no** form of the command.

Configuring DS1/T1 CT3 mode of STS-1

To configure DS1/T1 CT3 mode of STS-1, you can configure the T1 link using the following steps:

```
enable
configure terminal
controller sonet 0/0/16
sts-1 1
mode ct3
t1 1 clock source internal
t1 1 framing unframed
end
```

Note To restore the system to its default condition, use the **no** form of the command.

Configuring STS-Nc - Contiguous Concatenation

To configure STS-Nc - contiguous concatenation, use the following commands:

```
enable
configure terminal
controller sonet 0/0/16
sts-1 1-3 mode sts-3c
end
```

Note To restore the system to its default condition, use the **no** form of the command.

Note To configure STS-3c or STS-12c, use the numbers as multiples for 3 or 12, respectively.

Verification of SONET Configuration

The following sample output shows the verification of SONET configuration:

```
Router#show controllers sonet 0/0/16
SONET 0/0/16 is up.                                  ======> this is the controller/port
status.
  Hardware is

 Port configured rate: OC3                  =======> this is the rate the port is configured
 on it.
 Applique type is Channelized Sonet / SDH
 Clock Source is Line                            ===> the clocking config
Medium info:
  Type: Sonet, Line Coding: NRZ,
 SECTION:
  LOS = 0          LOF = 0                           =======> the section level alarm
counter (from last clear counters)

SONET Section Tables
  INTERVAL       CV   ES   SES   SEFS
  12:15-12:30     0    0     0      0
  12:00-12:15     0    0     0      0
  11:45-12:00    15    1     0      0 (Invalid)       =======> 1st PMON dataset. The 1st
dataset will always be flagged Invalid

Total of Data in Current and Previous Intervals
15     1     0     0 (Invalid)                                  ===> PMON for the port

LINE:
  AIS = 0          RDI = 0          REI = 0          BIP(B2) = 0    =======> the line level
 alarm counter (from last clear counters)
Active Defects: None
Detected Alarms: None
Asserted/Active Alarms: None                                  =========> present active
 alarms on the port.
Alarm reporting enabled for: SLOS SLOF SF B2-TCA
BER thresholds:  SF = 10e-3  SD = 10e-6                    ====> ber thresholds
TCA thresholds:   B2 = 10e-6
Rx: S1S0 = 00
    K1 = 00,   K2 = 00            ===> k1k2 values
    J0 = 00
    RX S1 = 00
Tx: S1S0 = 00
    K1 = 00,   K2 = 00
    J0 = 00

Tx J0 Length : 64
Tx J0 Trace :

  52 6F 75 74 65 72 20 20 20 20 20 20 20 20 20 20     Router
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 00 00                  ..

Expected J0 Length : 64
Expected J0 Trace :

  52 6F 75 74 65 72 20 20 20 20 20 20 20 20 20 20     Router
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 00 00                  ..

Rx J0 Length : 64
Rx J0 Trace :

  01 01 01 01 01 01 01 01 01 01 01 01 01 01 01 01     ................
  01 01 01 01 01 01 01 01 01 01 01 01 01 01 01 01     ................
```

```
  01 01 01 01 01 01 01 01 01 01 01 01 01 01 01 01     ................
  01 01 01 01 01 01 01 01 01 01 01 01 01 01 01 00     ................

SONET Line Tables
  INTERVAL       CV    ES   SES   UAS  CVFE  ESFE  SESFE  UASFE
  12:15-12:30     0     0     0    50     0     0      0      0 (FE Invalid)======> The Far
 End PMON dataset is flagged Invalid due to a Near End alarm.
  12:00-12:15     0     0     0     0     0     0      0      0
  11:45-12:00    48     1     0     0    53     1      0      0 (NE, FE Invalid)
Total of Data in Current and Previous Intervals
48     1     0    50    53     1      0      0 (NE, FE Invalid)


High Order Path:

PATH 1:
Clock Source is internal               ====> path level clock

  AIS = 0          RDI = 0          REI = 0          BIP(B3) = 0            ======>   path
 layer alarms counter
  LOP = 0          PSE = 0          NSE = 0          NEWPTR = 0
  LOM = 0          PLM = 0          UNEQ = 0

Active Defects: None
Detected Alarms: None
Asserted/Active Alarms: None                                          ======> present alarms
 on the path.
Alarm reporting enabled for: PAIS PRDI PUNEQ PLOP PPLM LOM B3-TCA

TCA threshold:  B3 = 10e-6
Rx: C2 = 00                                        =====> rx and tx C2 byte..
Tx: C2 = 02
PATH TRACE BUFFER : UNSTABLE

  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ……….       ====> path trace of the
path
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

SONET Path Tables
  INTERVAL       CV    ES   SES   UAS  CVFE  ESFE  SESFE  UASFE
  12:15-12:30     0     0     0     0     0     0      0    389 (FE Invalid)
  12:00-12:15     0     0     0     0     0     0      0      0
  11:45-12:00     0     1     1     0     0     0      0    900 (NE, FE Invalid)
Total of Data in Current and Previous Intervals
0     1     1     0     0     0      0   1289 (NE, FE Invalid)

PATH 2:
Clock Source is internal

  AIS = 0          RDI = 0          REI = 0          BIP(B3) = 0
  LOP = 0          PSE = 0          NSE = 0          NEWPTR = 0
  LOM = 0          PLM = 0          UNEQ = 0

Active Defects: None
Detected Alarms: None
Asserted/Active Alarms: PLOP
Alarm reporting enabled for: PAIS PRDI PUNEQ PLOP PPLM LOM B3-TCA

TCA threshold:  B3 = 10e-6
Rx: C2 = 00
Tx: C2 = 04
52 6F 75 74 65 72 20 30 2F 32 2F 30 2E 32 00 00     Router 0/2/0.2..
```

```
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

Expected J1 Length : 64
Expected J1 Trace

  52 6F 75 74 65 72 20 30 2F 32 2F 30 2E 32 00 00     Router 0/2/0.2..
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

PATH TRACE BUFFER : UNSTABLE

Rx J1 Length : 0
Rx J1 Trace


SONET Path Tables
  INTERVAL       CV    ES   SES   UAS  CVFE  ESFE  SESFE  UASFE
  12:15-12:30     0     0     0   389     0     0      0      0 (FE Invalid)
  12:00-12:15     0     0     0     0     0     0      0      0
  11:45-12:00     0     0     0   900     0     0      0      0 (NE, FE Invalid)
Total of Data in Current and Previous Intervals
0     0     0  1289     0     0      0      0 (NE, FE Invalid)

PATH 3:
Clock Source is internal

  AIS = 0          RDI = 0          REI = 0          BIP(B3) = 0
  LOP = 1          PSE = 0          NSE = 0          NEWPTR = 0
  LOM = 0          PLM = 0          UNEQ = 1

Active Defects: None
Detected Alarms: PLOP LOM
Asserted/Active Alarms: PLOP
Alarm reporting enabled for: PAIS PRDI PUNEQ PLOP PPLM LOM B3-TCA

TCA threshold:  B3 = 10e-6
Rx: C2 = 00
Tx: C2 = 02

Tx J1 Length : 64
Tx J1 Trace

  52 6F 75 74 65 72 20 30 2F 32 2F 30 2E 33 00 00     Router 0/2/0.3..
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

Expected J1 Length : 64
Expected J1 Trace

  52 6F 75 74 65 72 20 30 2F 32 2F 30 2E 33 00 00     Router 0/2/0.3..
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

PATH TRACE BUFFER : UNSTABLE

Rx J1 Length : 0
Rx J1 Trace
```

```
SONET Path Tables
  INTERVAL       CV    ES   SES   UAS  CVFE  ESFE  SESFE  UASFE
  12:15-12:30     0     0     0   389     0     0      0      0 (FE Invalid)
  12:00-12:15     0     0     0     0     0     0      0      0
  11:45-12:00     0     0     0   894     0     0      0      0 (NE, FE Invalid)
Total of Data in Current and Previous Intervals
0     0     0  1283     0     0      0      0 (NE, FE Invalid)

OC3.STS1 0/0/16 is up.    ======> present status of the path
  Hardware is

 Applique type is VT1.5    =====> mode of the path

 STS-1 1, VTG 1, T1 1 (VT1.5 1/1/1) is down   ====> status of the SPE (t1)
 VT Receiver has no alarm.
  Receiver is getting AIS.                              ===> alarm of the SPE (t1)
  Framing is unframed, Clock Source is Internal     =====> framing of the T1, clock of the
 t1
 Data in current interval (230 seconds elapsed):
   Near End
     0 Line Code Violations, 0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs, 0 Unavailable Secs
     0 Path Failures, 0 SEF/AIS Secs
   Far End
     0 Line Code Violations, 0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs, 0 Unavailable Secs
     0 Path Failures
  Data in Interval 1:
   Near End
     0 Line Code Violations, 0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 14 Line Err Secs, 0 Degraded Mins
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs, 15 Unavailable Secs
     1 Path Failures, 0 SEF/AIS Secs
   Far End Data
     0 Line Code Violations, 0 Path Code Violations
     0 Slip Secs, 4 Fr Loss Secs, 2 Line Err Secs, 0 Degraded Mins
     4 Errored Secs, 0 Bursty Err Secs, 4 Severely Err Secs, 0 Unavailable Secs
     0 Path Failures
  Total Data (last 1 15 minute intervals):
   Near End
     0 Line Code Violations, 0 Path Code Violations,
     0 Slip Secs, 0 Fr Loss Secs, 14 Line Err Secs, 0 Degraded Mins,
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs, 15 Unavailable Secs
     1 Path Failures, 0 SEF/AIS Secs
   Far End
     0 Line Code Violations, 0 Path Code Violations,
     0 Slip Secs, 4 Fr Loss Secs, 2 Line Err Secs, 0 Degraded Mins,
     4 Errored Secs, 0 Bursty Err Secs, 4 Severely Err Secs, 0 Unavailable Secs
     0 Path Failures

 STS-1 1, VTG 1, T1 2 (VT1.5 1/1/2) is down
 VT Receiver has no alarm.
  Receiver is getting AIS.
```

The following table shows each field and its description.

Table 9: Field Description

Field	Description
SONET 0/0/16 is up	Shows that the SONET controller is operating. The controller's state can be up, down, or administratively down.
Port configured rate: OC3	Shows the rate configured on the port.
SECTION: LOS = 0 LOF = 0 BIP = 0	Shows the section level alarm counters.
SONET Section Tables: INTERVAL CV ES SES SEFS 05:50-05:58 0 0 0 0	Shows the PMON for the port.
(Invalid)	Shows the PMON dataset is not valid and shouldn't be considered for performance analysis.
LINE: AIS = 0 RDI = 0 REI = 0 BIP(B2) = 0	Shows the line level alarm counters.
Asserted/Active Alarms: None	Shows the active alarms on the port.
BER thresholds: SF = 10e-3 SD = 10e-6	Shows BER thresholds.
K1 = 00, K2 = 00	Shows the K1 and K2 values.
PATH 1: Clock Source is internal	Shows the path level clock.
AIS = 0 RDI = 0 REI = 0 BIP(B3) = 0 LOP = 0 PSE = 0 NSE = 0 NEWPTR = 0 LOM = 0 PLM = 0 UNEQ = 0	Shows the path layer alarm counters.
Active Defects: None Detected Alarms: None Asserted/Active Alarms: None Alarm reporting enabled for: PLOP LOM B3-TCA	Shows the alarms on the path.
TCA threshold: B3 = 10e-6 Rx: C2 = 00 ======> rx and tx C2 byte.. Tx: C2 = 02 PATH TRACE BUFFER : UNSTABLE	shows the Rx and Tx C2 bytes.
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 …….	Shows the path trace.
OC3.STS1 0/3/3.1 is up.	Shows the status of the path.

Field	Description
Applique type is VT1.5	Shows the mode of the path.
STS-1 1, VTG 1, T1 1 (VT1.5 1/1/1) is down	Shows the status of SPE (T1).
Receiver is getting AIS.	Shows the alarm of SPE (T1).
Framing is unframed, Clock Source is Internal	Shows the framing of T1 and clock of the T1.

Clearing the PMON Data

The PMON data for the device is collected and stored every 15 minutes. A total of 96 PMON datasets are collected for a day (24 hours). You can view the PMON data by using the **show controller** command. However, if required, the dataset can be reset using the **clear counters** command.

Table 10: Feature History

Feature Name	Release Information	Description
Clear Counters command	Cisco IOS XE 17.15.1b	• Unlike the previous release, where the **clear counters** command reset the old dataset, from this release onwards, the command resets all the PMON datasets, including the current dataset. • You can clear the PMON data for a specific interface module on the device using the **clear controller hw-module** command



Note The **clear counters** command erases all the PMON data that can't be retrieved. Use the command carefully and only if necessary.

Following are the different **clear counters** command:

- Use the following command if you want to clear the PMON data for all interface modules on the device:

  ```
  clear counters
  ```

- Use the following command if you want to clear the PMON data for a specific interface module:

  ```
  clear controller hw-module <slot>
  ```

The command is useful in the following scenarios:

The command is useful when there is a need for a fresh set of data, like troubleshooting any network issues or monitoring the performance of a new configuration. After clearing, you can then monitor and analyze the new data that gets collected.

Configuring CEM Group for Framed SAToP

To configure a CEM group for Framed SAToP:

```
enable
configure terminal
controller mediatype 0/4/16
mode sonet
controller sonet 0/4/16
rate oc12
sts-1 1
mode vt-15
vtg 1 t1 1 cem-group 0 framed
end
```

Configuring VT-15 mode of STS-1 for Framed SAToP

To configure VT-15 mode of STS-1 for framed SAToP:

```
enable
configure terminal
controller mediatype 0/0/16
mode sonet
controller sonet 0/0/16
rate oc3
sts-1 1
mode vt-15
vtg 1 t1 1 cem-group 0 framed
end
```

Configuring DS1/T1 CT3 mode of STS-1 for Framed SAToP

To configure DS1/T1 CT3 mode of STS-1 for framed SAToP:

```
enable
configure terminal
controller mediatype 0/0/16
mode sonet
controller sonet 0/0/16
rate oc3
sts-1 2
mode ct3
t3 framing c-bit
t1 1 cem-group 1 framed
end
```

Performance Monitoring Use Cases or Deployment Scenarios for SONET

You can view the statistics or error count generated on the TDM lines.

To view the statistics or error count generated, use the **show controller sonet** command:

```
Router# show controller sonet 0/2/0
SONET 0/2/0 is up.
  Hardware is ASR900-1T8S-10CS

 Port configured rate: OC3
 Applique type is Channelized Sonet
 Clock Source is Internal
Medium info:
  Type: Sonet, Line Coding: NRZ,
```

```
 Alarm Throttling: OFF
 SECTION:
  LOS = 0          LOF = 0                          BIP(B1) = 0

SONET Section Tables
  INTERVAL       CV    ES   SES  SEFS
  12:00-12:07     0     0     0     0
  11:45-12:00    15     1     0     0 (Invalid)
Total of Data in Current and Previous Intervals
                 15     1     0     0 (Invalid)


LINE:
  AIS = 0          RDI = 0          REI = 0          BIP(B2) = 0
Active Defects: None
Detected Alarms: None
Asserted/Active Alarms: None
Alarm reporting enabled for: SLOS SLOF LAIS SF SD LRDI B1-TCA B2-TCA
BER thresholds:  SF = 10e-3  SD = 10e-6
TCA thresholds:  B1 = 10e-6  B2 = 10e-6
Rx: S1S0 = 00
    K1 = 00,   K2 = 00
    J0 = 00

    RX S1 = 00

Tx: S1S0 = 00
    K1 = 00,   K2 = 00
    J0 = 04

Tx J0 Length : 64
Tx J0 Trace :

  52 6F 75 74 65 72 20 20 20 20 20 20 20 20 20 20     Router
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 00 00                   ..

Expected J0 Length : 64
Expected J0 Trace :

  52 6F 75 74 65 72 20 20 20 20 20 20 20 20 20 20     Router
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 00 00                   ..

Rx J0 Length : 64
Rx J0 Trace :

  01 01 01 01 01 01 01 01 01 01 01 01 01 01 01 01     ................
  01 01 01 01 01 01 01 01 01 01 01 01 01 01 01 01     ................
  01 01 01 01 01 01 01 01 01 01 01 01 01 01 01 01     ................
  01 01 01 01 01 01 01 01 01 01 01 01 01 01 01 00     ................

SONET Line Tables
  INTERVAL       CV    ES   SES   UAS  CVFE  ESFE  SESFE  UASFE
  12:15-12:30     0     0     0    50     0     0      0      0 (FE Invalid)
  12:00-12:15     0     0     0     0     0     0      0      0
  11:45-12:00    48     1     0     0    53     1      0      0 (NE, FE Invalid)
Total of Data in Current and Previous Intervals
                 48     1     0    50    53     1      0      0 (NE, FE Invalid)


High Order Path:
```

```
PATH 1:
Clock Source is internal

  AIS = 0          RDI = 0          REI = 41350871   BIP(B3) = 9
  LOP = 0          PSE = 0          NSE = 0          NEWPTR = 0
  LOM = 0          PLM = 0          UNEQ = 1

Active Defects: None
Detected Alarms: None
Asserted/Active Alarms: None
Alarm reporting enabled for: PAIS PRDI PUNEQ PLOP PPLM LOM B3-TCA

TCA threshold:  B3 = 10e-6
Rx: C2 = 04
Tx: C2 = 04

Tx J1 Length : 64
Tx J1 Trace

  52 6F 75 74 65 72 20 30 2F 32 2F 30 2E 31 00 00     Router 0/2/0.1..
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

Expected J1 Length : 64
Expected J1 Trace

  52 6F 75 74 65 72 20 30 2F 32 2F 30 2E 31 00 00     Router 0/2/0.1..
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

PATH TRACE BUFFER : UNSTABLE

Rx J1 Length : 64
Rx J1 Trace

  BB 43 45 5F 31 5F 31 20 30 2F 34 2F 33 2E 31 00     .CE_1_1 0/4/3.1.
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

SONET Path Tables
  INTERVAL       CV    ES   SES   UAS  CVFE  ESFE  SESFE  UASFE
  12:15-12:30     0     0     0     0     0     0      0    389 (FE Invalid)
  12:00-12:15     0     0     0     0     0     0      0      0
  11:45-12:00     0     1     1     0     0     0      0    900 (NE, FE Invalid)
Total of Data in Current and Previous Intervals
                  0     1     1     0     0     0      0   1289 (NE, FE Invalid)

PATH 2:
Clock Source is internal

  AIS = 0          RDI = 0          REI = 0          BIP(B3) = 0
  LOP = 1          PSE = 0          NSE = 0          NEWPTR = 0
  LOM = 0          PLM = 0          UNEQ = 1

Active Defects: None
Detected Alarms: PLOP
Asserted/Active Alarms: PLOP
Alarm reporting enabled for: PAIS PRDI PUNEQ PLOP PPLM LOM B3-TCA

TCA threshold:  B3 = 10e-6
```

```
Rx: C2 = 00
Tx: C2 = 04

Tx J1 Length : 64
Tx J1 Trace

  52 6F 75 74 65 72 20 30 2F 32 2F 30 2E 32 00 00     Router 0/2/0.2..
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

Expected J1 Length : 64
Expected J1 Trace

  52 6F 75 74 65 72 20 30 2F 32 2F 30 2E 32 00 00     Router 0/2/0.2..
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

PATH TRACE BUFFER : UNSTABLE

Rx J1 Length : 0
Rx J1 Trace


SONET Path Tables
  INTERVAL       CV    ES   SES   UAS  CVFE  ESFE  SESFE  UASFE
  12:15-12:30     0     0     0   389     0     0      0      0 (FE Invalid)
  12:00-12:15     0     0     0     0     0     0      0      0
  11:45-12:00     0     0     0   900     0     0      0      0 (NE, FE Invalid)
Total of Data in Current and Previous Intervals
                  0     0     0  1289     0     0      0      0 (NE, FE Invalid)

PATH 3:
Clock Source is internal

  AIS = 0          RDI = 0          REI = 0          BIP(B3) = 0
  LOP = 1          PSE = 0          NSE = 0          NEWPTR = 0
  LOM = 0          PLM = 0          UNEQ = 1

Active Defects: None
Detected Alarms: PLOP LOM
Asserted/Active Alarms: PLOP
Alarm reporting enabled for: PAIS PRDI PUNEQ PLOP PPLM LOM B3-TCA

TCA threshold:  B3 = 10e-6
Rx: C2 = 00
Tx: C2 = 02

Tx J1 Length : 64
Tx J1 Trace

  52 6F 75 74 65 72 20 30 2F 32 2F 30 2E 33 00 00     Router 0/2/0.3..
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

Expected J1 Length : 64
Expected J1 Trace

  52 6F 75 74 65 72 20 30 2F 32 2F 30 2E 33 00 00     Router 0/2/0.3..
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
```

```
PATH TRACE BUFFER : UNSTABLE

Rx J1 Length : 0
Rx J1 Trace


SONET Path Tables
  INTERVAL       CV    ES   SES   UAS  CVFE  ESFE  SESFE  UASFE
  12:15-12:30     0     0     0   389     0     0      0      0 (FE Invalid)
  12:00-12:15     0     0     0     0     0     0      0      0
  11:45-12:00     0     0     0   900     0     0      0      0 (NE, FE Invalid)
Total of Data in Current and Previous Intervals
                  0     0     0  1289     0     0      0      0 (NE, FE Invalid)


SONET 0/2/0.1 T3 is down.
  ASR900-1T8S-10CS

  Applique type is T3
  Receiver is getting AIS.
  MDL transmission is disabled

  FEAC code received: No code is being received
  Framing is C-BIT Parity, Cablelength is 224
  BER thresholds:  SF = 10e-3  SD = 10e-6
  Clock Source is internal
  Equipment customer loopback
  Data in current interval (390 seconds elapsed):
   Near End
     0 Line Code Violations, 0 P-bit Coding Violations
     0 C-bit Coding Violations, 0 P-bit Err Secs
     0 P-bit Severely Err Secs, 0 Severely Err Framing Secs
     389 Unavailable Secs, 0 Line Errored Secs
     0 C-bit Errored Secs, 0 C-bit Severely Errored Secs
     0 Severely Errored Line Secs, 0 Path Failures
     0 AIS Defect Secs, 0 LOS Defect Secs
   Far End
     0 Errored Secs, 0 Severely Errored Secs
     0 C-bit Unavailable Secs, 0 Path Failures
     0 Code Violations, 0 Service Affecting Secs
  Data in Interval 1:
   Near End
     0 Line Code Violations, 0 P-bit Coding Violations
     0 C-bit Coding Violations, 0 P-bit Err Secs
     0 P-bit Severely Err Secs, 0 Severely Err Framing Secs
     910 Unavailable Secs, 0 Line Errored Secs
     0 C-bit Errored Secs, 0 C-bit Severely Errored Secs
     0 Severely Errored Line Secs, 1 Path Failures
     0 AIS Defect Secs, 0 LOS Defect Secs
   Far End
     0 Errored Secs, 0 Severely Errored Secs
     0 C-bit Unavailable Secs, 0 Path Failures
     0 Code Violations, 0 Service Affecting Secs
  Total Data (last 1 15 minute intervals):
   Near End
     0 Line Code Violations, 0 P-bit Coding Violations,
     0 C-bit Coding Violations, 0 P-bit Err Secs,
     0 P-bit Severely Err Secs, 0 Severely Err Framing Secs,
     910 Unavailable Secs, 0 Line Errored Secs,
     0 C-bit Errored Secs, 0 C-bit Severely Errored Secs
     0 Severely Errored Line Secs, 1 path failures
     0 AIS Defect Secs, 0 LOS Defect Secs
   Far End
```

```
     0 Errored Secs, 0 Severely Errored Secs
     0 C-bit Unavailable Secs, 0 Path Failures
     0 Code Violations, 0 Service Affecting Secs

  T1 1 is up
  timeslots:
  FDL per AT&T 54016 spec.
  No alarms detected.
  Framing is ESF, Clock Source is Internal
  Data in current interval (250 seconds elapsed):
   Near End
     0 Line Code Violations, 0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
     0 Unavailable Secs, 0 Stuffed Secs
     0 Path Failures, 0 SEF/AIS Secs
   Far End
     0 Line Code Violations, 0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
     0 Unavailable Secs 0 Path Failures
  Data in Interval 1:
   Near End
     0 Line Code Violations, 0 Path Code Violations
     0 Slip Secs, 2 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
     2 Errored Secs, 0 Bursty Err Secs, 2 Severely Err Secs
     0 Unavailable Secs, 0 Stuffed Secs
     1 Path Failures, 2 SEF/AIS Secs
   Far End
     0 Line Code Violations, 0 Path Code Violations
     0 Slip Secs, 2 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
     3 Errored Secs, 0 Bursty Err Secs, 3 Severely Err Secs
     0 Unavailable Secs 0 Path Failures
  Total Data (last 1 15 minute intervals):
   Near End
     0 Line Code Violations,0 Path Code Violations,
     0 Slip Secs, 2 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins,
     2 Errored Secs, 0 Bursty Err Secs, 2 Severely Err Secs
     0 Unavailable Secs, 0 Stuffed Secs
     1 Path Failures, 2 SEF/AIS Secs
   Far End
     0 Line Code Violations,0 Path Code Violations
     0 Slip Secs, 2 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins,
     3 Errored Secs, 0 Bursty Err Secs, 3 Severely Err Secs
     0 Unavailable Secs, 0 Path Failures

SONET 0/2/0.2 T3 is down.
  Hardware is ASR900-1T8S-10CS

  Applique type is Channelized T3 to T1
  Receiver is getting AIS.
  MDL transmission is disabled

  FEAC code received: No code is being received
  Framing is C-BIT Parity, Cablelength is 224
  BER thresholds:  SF = 10e-3  SD = 10e-6
  Clock Source is internal
  Equipment customer loopback
  Data in current interval (400 seconds elapsed):
   Near End
     0 Line Code Violations, 0 P-bit Coding Violations
     0 C-bit Coding Violations, 0 P-bit Err Secs
     0 P-bit Severely Err Secs, 0 Severely Err Framing Secs
     399 Unavailable Secs, 0 Line Errored Secs
```

```
    0 C-bit Errored Secs, 0 C-bit Severely Errored Secs
    0 Severely Errored Line Secs, 0 Path Failures
    0 AIS Defect Secs, 0 LOS Defect Secs
  Far End
    0 Errored Secs, 0 Severely Errored Secs
    0 C-bit Unavailable Secs, 0 Path Failures
    0 Code Violations, 0 Service Affecting Secs
 Data in Interval 1:
  Near End
    0 Line Code Violations, 0 P-bit Coding Violations
    0 C-bit Coding Violations, 0 P-bit Err Secs
    0 P-bit Severely Err Secs, 0 Severely Err Framing Secs
    910 Unavailable Secs, 0 Line Errored Secs
    0 C-bit Errored Secs, 0 C-bit Severely Errored Secs
    0 Severely Errored Line Secs, 1 Path Failures
    0 AIS Defect Secs, 0 LOS Defect Secs
  Far End
    0 Errored Secs, 0 Severely Errored Secs
    0 C-bit Unavailable Secs, 0 Path Failures
    0 Code Violations, 0 Service Affecting Secs
 Total Data (last 1 15 minute intervals):
  Near End
    0 Line Code Violations, 0 P-bit Coding Violations,
    0 C-bit Coding Violations, 0 P-bit Err Secs,
    0 P-bit Severely Err Secs, 0 Severely Err Framing Secs,
    910 Unavailable Secs, 0 Line Errored Secs,
    0 C-bit Errored Secs, 0 C-bit Severely Errored Secs
    0 Severely Errored Line Secs, 1 path failures
    0 AIS Defect Secs, 0 LOS Defect Secs
  Far End
    0 Errored Secs, 0 Severely Errored Secs
    0 C-bit Unavailable Secs, 0 Path Failures
    0 Code Violations, 0 Service Affecting Secs
T1 1 is up
 timeslots:
 FDL per AT&T 54016 spec.
 No alarms detected.
 Framing is ESF, Clock Source is Internal
 Data in current interval (250 seconds elapsed):
  Near End
    0 Line Code Violations, 0 Path Code Violations
    0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
    0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
    0 Unavailable Secs, 0 Stuffed Secs
    0 Path Failures, 0 SEF/AIS Secs
  Far End
    0 Line Code Violations, 0 Path Code Violations
    0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
    0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
    0 Unavailable Secs 0 Path Failures
 Data in Interval 1:
  Near End
    0 Line Code Violations, 0 Path Code Violations
    0 Slip Secs, 2 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
    2 Errored Secs, 0 Bursty Err Secs, 2 Severely Err Secs
    0 Unavailable Secs, 0 Stuffed Secs
    1 Path Failures, 2 SEF/AIS Secs
  Far End
    0 Line Code Violations, 0 Path Code Violations
    0 Slip Secs, 2 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
    3 Errored Secs, 0 Bursty Err Secs, 3 Severely Err Secs
    0 Unavailable Secs 0 Path Failures
 Total Data (last 1 15 minute intervals):
  Near End
```

```
     0 Line Code Violations,0 Path Code Violations,
     0 Slip Secs, 2 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins,
     2 Errored Secs, 0 Bursty Err Secs, 2 Severely Err Secs
     0 Unavailable Secs, 0 Stuffed Secs
     1 Path Failures, 2 SEF/AIS Secs
   Far End
     0 Line Code Violations,0 Path Code Violations
     0 Slip Secs, 2 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins,
     3 Errored Secs, 0 Bursty Err Secs, 3 Severely Err Secs
     0 Unavailable Secs, 0 Path Failures
 STS-1 2, T1 1 (CT3 2-1) is down
  timeslots:
  FDL per ANSI T1.403 and AT&T 54016 spec.
  Receiver is getting AIS.
  Framing is ESF, Clock Source is Internal
  Data in current interval (390 seconds elapsed):
   Near End
     0 Line Code Violations, 0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
     389 Unavailable Secs, 0 Stuffed Secs
   Far End
     0 Line Code Violations, 0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
     0 Unavailable Secs
  Data in Interval 1:
   Near End
     0 Line Code Violations, 0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
     900 Unavailable Secs, 0 Stuffed Secs
   Far End
     0 Line Code Violations, 0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
     0 Unavailable Secs
  Total Data (last 1 15 minute intervals):
   Near End
     0 Line Code Violations,0 Path Code Violations,
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins,
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
     900 Unavailable Secs, 0 Stuffed Secs
   Far End
     0 Line Code Violations,0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins,
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
     0 Unavailable Secs
```

To view the performance monitoring details on SONET, use the **show controller sonet tabular** command:

```
Router#show controllers sonet 0/7/19 tabular

SONET 0/7/19 is up.
  Hardware is A900-IMA3G-IMSG NCS4200-3GMS

Port configured rate: OC3
Applique type is Channelized Sonet
Clock Source is Internal
Medium info:
  Type: Sonet, Line Coding: NRZ,
 Alarm Throttling: OFF
SECTION:
  LOS = 0          LOF = 0                            BIP(B1) = 0
```

```
SONET Section Tables
  INTERVAL       CV-S    ES-S   SES-S  SEFS-S
  11:33-11:47       0       0       0       0 (NE, FE Invalid)

LINE:
  AIS = 0          RDI = 0          REI = 0          BIP(B2) = 0
Active Defects: None
Detected Alarms: None
Asserted/Active Alarms: None
Alarm reporting enabled for: SLOS SLOF LAIS SF SD LRDI B1-TCA B2-TCA
BER thresholds:  SF = 10e-3  SD = 10e-6
TCA thresholds:  B1 = 10e-6  B2 = 10e-6
Rx: S1S0 = NA
    K1 = 00,   K2 = 00
    J0 = 00

    RX S1 = 00

Tx: S1S0 = NA
    K1 = 00,   K2 = 00
    J0 = 04

Tx J0 Length : 64
Tx J0 Trace :

  50 45 32 20 20 20 20 20 20 20 20 20 20 20 20 20     PE2
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 00 00                  ..

Expected J0 Length : 64
Expected J0 Trace :

  50 45 32 20 20 20 20 20 20 20 20 20 20 20 20 20     PE2
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 00 00                  ..

Rx J0 Length : 64
Rx J0 Trace :

  50 45 32 20 20 20 20 20 20 20 20 20 20 20 20 20     PE2
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 0D 00                  ..

SONET Line Tables
  INTERVAL     CV-L  ES-L  SES-L  UAS-L  CV-LFE  ES-LFE  SES-LFE  UAS-LFE
  11:33-11:47     0     0      0      0       0       0        0        0 (NE, FE Invalid)

APS
  BERSF = 0          BERSD = 0
  Active Alarms: None


PATH 1:
Clock Source is internal

  AIS = 0          RDI = 0          REI = 0          BIP(B3) = 0
  LOM = 0          PLM = 0          UNEQ = 0          LOP = 0

Active Defects: None
Detected Alarms: None
```

```
Asserted/Active Alarms: None
Alarm reporting enabled for: PAIS PRDI PUNEQ PLOP PPLM LOM B3-SF B3-SD B3-TCA

BER threshold:  SF = 10e-3  SD = 10e-6
TCA threshold:  B3 = 10e-6
Rx: C2 = 04
Tx: C2 = 04

Tx J1 Length : 64
Tx J1 Trace

  50 45 32 20 30 2F 37 2F 31 39 2E 31 00 00 00 00     PE2 0/7/19.1....
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

Expected J1 Length : 64
Expected J1 Trace

  50 45 32 20 30 2F 37 2F 31 39 2E 31 00 00 00 00     PE2 0/7/19.1....
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

Rx J1 Length : 64
Rx J1 Trace

  50 45 32 20 30 2F 39 2F 37 2E 31 00 00 00 00 00     PE2 0/9/7.1.....
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

SONET Path Tables
  INTERVAL     CV-P  ES-P  SES-P  UAS-P  CV-PFE  ES-PFE  SES-PFE  UAS-PFE
  11:33-11:47     0     0      0      0       0       0        0        0 (NE, FE Invalid)

PATH 2:
Clock Source is internal

  AIS = 0          RDI = 0          REI = 0          BIP(B3) = 0
  LOM = 0          PLM = 0          UNEQ = 0          LOP = 0

Active Defects: None
Detected Alarms: None
Asserted/Active Alarms: None
Alarm reporting enabled for: PAIS PRDI PUNEQ PLOP PPLM LOM B3-SF B3-SD B3-TCA

BER threshold:  SF = 10e-3  SD = 10e-6
TCA threshold:  B3 = 10e-6
Rx: C2 = 00
Tx: C2 = 00

Tx J1 Length : 64
Tx J1 Trace

  50 45 32 20 30 2F 37 2F 31 39 2E 32 00 00 00 00     PE2 0/7/19.2....
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

Expected J1 Length : 64
Expected J1 Trace

  50 45 32 20 30 2F 37 2F 31 39 2E 32 00 00 00 00     PE2 0/7/19.2....
```

```
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

Rx J1 Length : 0
Rx J1 Trace


SONET Path Tables
  INTERVAL     CV-P  ES-P  SES-P  UAS-P  CV-PFE  ES-PFE  SES-PFE  UAS-PFE
  11:47-11:47     0     0      0      0       0       0        0        0 (NE, FE Invalid)

PATH 3:
Clock Source is internal

  AIS = 0          RDI = 0          REI = 0          BIP(B3) = 0
  LOM = 0          PLM = 0          UNEQ = 0          LOP = 0

Active Defects: None
Detected Alarms: None
Asserted/Active Alarms: None
Alarm reporting enabled for: PAIS PRDI PUNEQ PLOP PPLM LOM B3-SF B3-SD B3-TCA

BER threshold:  SF = 10e-3  SD = 10e-6
TCA threshold:  B3 = 10e-6
Rx: C2 = 00
Tx: C2 = 00

Tx J1 Length : 64
Tx J1 Trace

  50 45 32 20 30 2F 37 2F 31 39 2E 33 00 00 00 00     PE2 0/7/19.3....
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

Expected J1 Length : 64
Expected J1 Trace

  50 45 32 20 30 2F 37 2F 31 39 2E 33 00 00 00 00     PE2 0/7/19.3....
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

Rx J1 Length : 0
Rx J1 Trace


SONET Path Tables
  INTERVAL     CV-P  ES-P  SES-P  UAS-P  CV-PFE  ES-PFE  SES-PFE  UAS-PFE
  11:47-11:47     0     0      0      0       0       0        0        0 (NE, FE Invalid)


SONET 0/7/19.1 T3 is up.
  Hardware is NCS4200-3GMS

  Applique type is T3
  No alarms detected.
  MDL transmission is disabled

  FEAC code received: No code is being received
  Framing is C-BIT Parity, Cablelength is 224
  BER thresholds:  SF = 10e-3  SD = 10e-6
  Clock Source is internal
```

```
  Equipment customer loopback
  Near End Data
  INTERVAL      CV-L  ES-L  SES-L LOSS-L  CVP-P CVCP-P  ESP-P ESCP-P SESP-P SESCP-P  SAS-P
 AISS-P  FC-P UASP-P UASCP-P
  11:33-11:47      0     0      0      0      0      0      0      0      0       0      0
      0     0      0       0 (Invalid)
  Far End Data
  INTERVAL      CVCP-PFE  ESCP-PFE  SESCP-PFE  UASCP-PFE  FCCP-PFE  SASCP-PFE
  11:33-11:47          0         0          0          0         0          0 (Invalid)
```

Table 11: Feature History

Feature Name	Release Information	Description
GR-820-CORE specific Performance Monitoring	Cisco IOS XE Bengaluru 17.5.1	The **show controller tabular**enables you to view the performance monitoring details in tabular form as per GR-820-Core standards.

To view the performance monitoring details on T3 interface, use the **show controller t3 tabular** command:

```
Router#show controllers t3 0/7/12 tabular
T3 0/7/12 is down.
  Hardware is
  Applique type is Subrate T3
  Receiver has loss of signal.
  MDL transmission is disabled

  FEAC code received: No code is being received
  Framing is C-BIT Parity, Line Code is B3ZS, Cablelength Short less than 225ft
  BER thresholds:  SF = 10e-3  SD = 10e-6
  Clock Source is internal
  Equipment customer loopback
  Near End Data
  INTERVAL      CV-L  ES-L  SES-L LOSS-L  CVP-P CVCP-P  ESP-P ESCP-P SESP-P SESCP-P  SAS-P
 AISS-P  FC-P UASP-P UASCP-P
  11:33-11:46      0   779    779    779      0      0      0      0      0       0      0
      0     0    779     779 (Invalid)
  Far End Data
  INTERVAL      CVCP-PFE  ESCP-PFE  SESCP-PFE  UASCP-PFE  FCCP-PFE  SASCP-PFE
  11:33-11:46          0         0          0          0         0          0 (Invalid)
```

To view the performance monitoring details on T1 interface, use the **show controller t1 tabular** command:

```
Router#show controllers t1 0/7/0 tabular
T1 0/7/0 is down
  Applique type is
  Receiver has loss of signal.
  alarm-trigger is not set
  Soaking time: 3, Clearance time: 10
  Framing is ESF, Line Code is B8ZS, Clock Source is Line.
  BER thresholds:  SF = 10e-3  SD = 10e-6
  Near End Data
  INTERVAL     CV-L   ES-L   CV-P   ES-P  SES-P  CSS-P  SAS-P  UAS-P   FC-P
  10:48-10:57     0    530      0      0      0      0      0    530      1 (Invalid)
  Far End Data
  INTERVAL     ES-LFE  ES-PFE  SES-PFE  SEFS-PFE  CSS-PFE  UAS-PFE  FC-PFE
  10:48-10:57       0       0        0         0        0        0       0 (Invalid)
```

Starting with Cisco IOS XE 17.11.1, you can view the previous day performance monitoring details using the following **`show controller`** commands for the T1 or E1, T3 or E3, and SONET controllers.

- show controllers sonet

- show controllers sonet tabular
- show controllers sonet remote performance
- show controllers sonet remote performance tabular

```
router#show controllers sonet 0/3/0

SONET 0/3/0 is down.
  Hardware is A900-IMA1Z8S-CX

 Port configured rate: OC3
 Applique type is Channelized Sonet
 Clock Source is Internal
Medium info:
  Type: Sonet, Line Coding: NRZ,
 Alarm Throttling: OFF
 SECTION:
  LOS = 1          LOF = 0                          BIP(B1) = 0

SONET Section Tables
  INTERVAL       CV    ES   SES  SEFS
  06:14-06:24     0   611   611   611
  05:59-06:14     0   901   901   901
.............
  06:29-06:44     0   901   901   901
  06:14-06:29     0   901   901   901 (NE, FE Invalid)
Total of Data in Current and Previous Intervals
                  0 87107 87107 87107 (NE, FE Invalid)
Total (Previous Day)
  05:29-05:29     0 86494 86494 86494 (NE, FE Invalid)

LINE:
  AIS = 0          RDI = 0          REI = 0          BIP(B2) = 0
Active Defects: None
Detected Alarms: SLOS SLOF LAIS
Asserted/Active Alarms: SLOS
.............
SONET Line Tables
  INTERVAL       CV    ES   SES   UAS  CVFE  ESFE  SESFE  UASFE
  06:14-06:24     0     0     0   611     0     0      0      0
  05:59-06:14     0     0     0   901     0     0      0      0
  05:44-05:59     0     0     0   901     0     0      0      0
  05:29-05:44     0     0     0   901     0     0      0      0
.............
  06:14-06:29     0     0     0   901     0     0      0      0 (NE, FE Invalid)
Total of Data in Current and Previous Intervals
                  0     0     0 87107     0     0      0      0 (NE, FE Invalid)
Total (Previous Day)
  05:29-05:29     0     0     0 86494     0     0      0      0 (NE, FE Invalid)


PATH 1:
Clock Source is internal

  AIS = 0          RDI = 0          REI = 0          BIP(B3) = 8
  LOM = 0          PLM = 0          UNEQ = 0          LOP = 0
..............

SONET Path Tables
  INTERVAL       CV    ES   SES   UAS  CVFE  ESFE  SESFE  UASFE
  06:14-06:24     0     0     0   609     0     0      0      0
  05:59-06:14     0     0     0   901     0     0      0      0
```

```
  05:44-05:59     0     0     0   900     0     0      0      0
  05:29-05:44     0     0     0   901     0     0      0      0
.................
  06:29-06:44     0     0     0   900     0     0      0      0
  06:14-06:29     0     0     0   900     0     0      0      0 (NE, FE Invalid)
Total of Data in Current and Previous Intervals
                  0     0     0 87045     0     0      0      0 (NE, FE Invalid)
Total (Previous Day)
  05:29-05:29     0     0     0 86435     0     0      0      0 (NE, FE Invalid)

PATH 2:
Clock Source is internal
.................

SONET 0/3/0.1 PATH  is down.
  Hardware is A900-IMA1Z8S-CX

 Applique type is VT1.5

 STS-1 1, VTG 1, VT 1 (SONET 0/3/0.1/1/1 VT) is down
 VT Receiver has LP_AIS.
  cep is configured: FALSE cem_id  (0)
  fwd_alarm_ais :0    fwd_alarm_rai :0, Clock Source is Internal
  BIP2-tca:6, BIP2-sf:3, BIP2-sd:6
  Tx V5:2
  Rx V5:0
  Tx J2 Length=64
  TX J2 Trace Buffer:
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

  Expected J2 Length=64
  Expected J2 Trace Buffer:
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

  Rx J2 Length=16
  RX J2 Trace Buffer:
  CRC-7: 0x60 ERROR

  C9 79 F7 0F 5F D8 5D D2 D2 7C F6 0E 53 B2 0E 00     .y.._.]..|..S...

 Data in curerent interval (610 seconds elapsed)
   Near End
    0 CodeViolations, 0 ErrorSecs, 0 Severly Err Secs, 609 Unavailable Secs
   Far End
    0 CodeViolations, 0 ErrorSecs, 0 Severly Err Secs, 0 Unavailable Secs
 Data in Interval 1:
   Near End
    0 CodeViolations, 0 ErrorSecs, 0 Severly Err Secs, 901 Unavailable Secs
   Far End
    0 CodeViolations, 0 ErrorSecs, 0 Severly Err Secs, 0 Unavailable Secs
.................
 Data in Interval 96:
   Near End
    0 CodeViolations, 0 ErrorSecs, 0 Severly Err Secs, 900 Unavailable Secs
   Far End
    0 CodeViolations, 0 ErrorSecs, 0 Severly Err Secs, 0 Unavailable Secs
 Total Data (last 96 fifteen minute intervals):
   Near End
```

```
    0 CodeViolations, 0 ErrorSecs, 0 Severly Err Secs, 86436 Unavailable Secs
   Far End
    0 CodeViolations, 0 ErrorSecs, 0 Severly Err Secs, 0 Unavailable Secs
 Total (Previous Day):
   Near End
    0 CodeViolations, 0 ErrorSecs, 0 Severly Err Secs, 86435 Unavailable Secs
   Far End
    0 CodeViolations, 0 ErrorSecs, 0 Severly Err Secs, 0 Unavailable Secs


 STS-1 1, VTG 1, T1 1 (SONET 0/3/0.1/1/1 T1) is down
  timeslots: 1-4
  FDL per AT&T 54016 spec.
  Receiver is getting AIS.
  Framing is ESF, Clock Source is Internal
  Data in current interval (610 seconds elapsed):
   Near End
     0 Line Code Violations, 0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
     609 Unavail Secs, 0 Stuffed Secs
   Far End
     0 Line Code Violations, 0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
     0 Unavail Secs
  Data in Interval 1:
   Near End
     0 Line Code Violations, 0 Path Code Violations
.....................
   Far End
     0 Line Code Violations, 0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
     0 Unavail Secs
  Data in Interval 96:
   Near End
     0 Line Code Violations, 0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
     900 Unavail Secs, 0 Stuffed Secs
   Far End
     0 Line Code Violations, 0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
     0 Unavail Secs
  Total Data (last 24 hours)
   Near End
     0 Line Code Violations,0 Path Code Violations,
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins,
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
     86436 Unavail Secs, 0 Stuffed Secs
   Far End
     0 Line Code Violations,0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins,
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
     0 Unavailable Secs
  Total (Previous Day)
   Near End
     0 Line Code Violations,0 Path Code Violations,
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins,
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
     86435 Unavail Secs, 0 Stuffed Secs
   Far End
```

```
     0 Line Code Violations,0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins,
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
     0 Unavailable Secs

 STS-1 1, VTG 1, VT 2 (SONET 0/3/0.1/1/2 VT) is down
 VT Receiver has LP_AIS.


router#show controllers sonet 0/3/0 tabular

Section/Line/Path same as previous.

SONET 0/3/0.1 PATH  is down.
  Hardware is A900-IMA1Z8S-CX

 Applique type is VT1.5

 STS-1 1, VTG 1, VT 1 (SONET 0/3/0.1/1/1 VT) is down
 VT Receiver has LP_AIS.
  cep is configured: FALSE cem_id  (0)
  fwd_alarm_ais :0    fwd_alarm_rai :0, Clock Source is Internal
  BIP2-tca:6, BIP2-sf:3, BIP2-sd:6
  Tx V5:2
  Rx V5:0
  Tx J2 Length=64
  TX J2 Trace Buffer:
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

  Expected J2 Length=64
  Expected J2 Trace Buffer:
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

  Rx J2 Length=16
  RX J2 Trace Buffer:
  CRC-7: 0x60 ERROR

  C9 79 F7 0F 5F D8 5D D2 D2 7C F6 0E 53 B2 0E 00     .y.._.]..|..S...

 INTERVAL     CV-V  ES-V  SES-V  UAS-V  CV-VFE  ES-VFE  SES-VFE  UAS-VFE
 06:14-06:24     0     0      0    619       0       0        0        0
 05:59-06:14     0     0      0    901       0       0        0        0
 05:44-05:59     0     0      0    900       0       0        0        0
 05:29-05:44     0     0      0    901       0       0        0        0
 05:14-05:29     0     0      0    900       0       0        0        0
 04:59-05:14     0     0      0    900       0       0        0        0
.....................
 06:44-06:59     0     0      0    901       0       0        0        0
 06:29-06:44     0     0      0    900       0       0        0        0
 06:14-06:29     0     0      0    900       0       0        0        0 (NE, FE Invalid)
 Total           0     0      0  86436       0       0        0        0 (NE, FE Invalid)
 Total (Previous Day):
 05:29-05:29     0     0      0  86435       0       0        0        0 (NE, FE Invalid)


 STS-1 1, VTG 1, T1 1 (SONET 0/3/0.1/1/1 T1) is down
  timeslots: 1-4
  FDL per AT&T 54016 spec.
  Receiver is getting AIS.
```

```
  Framing is ESF, Clock Source is Internal
  Near End Data
  INTERVAL     CV-L   ES-L   CV-P   ES-P  SES-P  CSS-P  SAS-P  UAS-P   FC-P
  06:14-06:24     0      0      0      0      0      0      0    619      0
  05:59-06:14     0      0      0      0      0      0      0    901      0
..............
  06:44-06:59     0      0      0      0      0      0      0    901      0
  06:29-06:44     0      0      0      0      0      0      0    900      0
  06:14-06:29     0      0      0      0      0      0      0    900      0 (Invalid)
  Total           0      0      0      0      0      0      0  86436      0 (Invalid)
  Total (Previous Day):
  05:29-05:29     0      0      0      0      0      0      0  86435      0 (Invalid)
  Far End Data
  INTERVAL     ES-LFE  ES-PFE  SES-PFE  SEFS-PFE  CSS-PFE  UAS-PFE  FC-PFE
  06:14-06:24       0       0        0         0        0        0       0
  05:59-06:14       0       0        0         0        0        0       0
.....................
  06:29-06:44       0       0        0         0        0        0       0
  06:14-06:29       0       0        0         0        0        0       0 (Invalid)
  Total             0       0        0         0        0        0       0 (Invalid)
  Total (Previous Day):
  05:29-05:29       0       0        0         0        0        0       0 (Invalid)

 STS-1 1, VTG 1, VT 2 (SONET 0/3/0.1/1/2 VT) is down
 VT Receiver has LP_AIS.
  cep is configured: FALSE cem_id  (0)
  fwd_alarm_ais :0    fwd_alarm_rai :0, Clock Source is Internal

router#show controllers sonet 0/3/0 remote performance

Section/Line/Path same as previous.

SONET 0/3/0.1 PATH  is down.
  Hardware is A900-IMA1Z8S-CX


 STS-1 1, VTG 1, VT 1 (VT1.5 1/1/1) - Remote Performance Data
 Far end MIB Data:
 Data in curerent interval (630 seconds elapsed)
 0 CodeViolations , 0 ErrorSecs,0 Severly Err Secs, 0 Unavail Secs
 FarEnd VT Interval data:
 Total Data (last 96 15 minute intervals):
 0 CodeViolations, 0 ErrorSec,  0 Severly Err Secs, 0 Unavail Secs

 Total (Previous Day):
 0 CodeViolations, 0 ErrorSec,  0 Severly Err Secs, 0 Unavail Secs


 STS-1 1, VTG 1, T1 1 (SONET 0/3/0.1/1/1 T1) - Remote Performance Data
  Data in current interval (630 seconds elapsed):
     0 Line Code Violations, 0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
     0 Unavail Secs
  Data in Interval 1:
.................
  Data in Interval 96:
     0 Line Code Violations, 0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
     0 Unavail Secs
  Total Data (last 24 hours)
     0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins,
```

```
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
     0 Unavail Secs
  Total (Previous Day)
     0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins,
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
     0 Unavail Secs

 STS-1 1, VTG 1, VT 2 (VT1.5 1/1/2) - Remote Performance Data
 Far end MIB Data:
 Data in curerent interval (630 seconds elapsed)
 0 CodeViolations , 0 ErrorSecs,0 Severly Err Secs, 0 Unavail Secs
 FarEnd VT Interval data:
 Total Data (last 96 15 minute intervals):
 0 CodeViolations, 0 ErrorSec,  0 Severly Err Secs, 0 Unavail Secs

 Total (Previous Day):
 0 CodeViolations, 0 ErrorSec,  0 Severly Err Secs, 0 Unavail Secs


router#show controllers sonet 0/3/0 remote performance tabular

Section/Line/Path same as previous.


SONET 0/3/0.1 PATH  is down.
  Hardware is A900-IMA1Z8S-CX


 STS-1 1, VTG 1, VT 1 (VT1.5 1/1/1) - Remote Performance Data
 Far end MIB Data:
 INTERVAL       CV     ES    SES   UAS
 06:14-06:24     0     0     0     0
 FarEnd VT Interval data:
 INTERVAL       CV     ES    SES   UAS
  05:59-06:14     0     0     0     0

  05:44-05:59     0     0     0     0

  05:29-05:44     0     0     0     0

  05:14-05:29     0     0     0     0
..................
  06:29-06:44     0     0     0     0

  06:14-06:29     0     0     0     0

 Total
  CV    ES   SES   UAS    0     0     0     0

 Total (Previous Day)
  CV    ES   SES   UAS    0     0     0     0


 STS-1 1, VTG 1, T1 1 (SONET 0/3/0.1/1/1 T1) - Remote Performance Data
  INTERVAL      LCV   PCV   CSS  SELS   LES    DM    ES   BES   SES   UAS
  06:14-06:24     0     0     0     0     0     0     0     0     0     0
  05:59-06:14     0     0     0     0     0     0     0     0     0     0
  05:44-05:59     0     0     0     0     0     0     0     0     0     0
.....................
  06:44-06:59     0     0     0     0     0     0     0     0     0     0
  06:29-06:44     0     0     0     0     0     0     0     0     0     0
  06:14-06:29     0     0     0     0     0     0     0     0     0     0
  Total           0     0     0     0     0     0     0     0     0     0 (NE, FE Invalid)
  Total (Previous Day)
```

```
 05:29-05:29     0     0     0     0     0     0     0     0     0     0 (NE, FE Invalid)

STS-1 1, VTG 1, VT 2 (VT1.5 1/1/2) - Remote Performance Data
Far end MIB Data:
INTERVAL       CV     ES    SES   UAS
06:14-06:24     0     0     0     0 (Invalid)
FarEnd VT Interval data:
INTERVAL       CV     ES    SES   UAS
 05:59-06:14     0     0     0     0 (Invalid)
```

Table 12: Feature History

Feature Name	Release Information	Description
Invalid Flag attribute in performance monitoring data (PMON)	Cisco IOS XE 17.15.1b	A new attribute, "Invalid," is introduced in the PMON data in the **show controller** output. The "Invalid" flag associated with Near End and Far End datasets indicates that the dataset isn't valid and shouldn't be considered for performance analysis.

The "Invalid" attribute is implemented for the following **`show controller`** commands:

- show controllers sonet
- show controllers sonet tabular
- show controllers sonet remote performance
- show controllers sonet remote performance tabular

Note The "Invalid" flag attribute isn't supported for A900-IMA1Z8S-CX.

The "Invalid" flag is associated with each Near End and Far End PMON dataset, generated every 15 minutes to precisely identify the time frame of the occurrence of the alarm.

- The first instance of the Near End and Far End PMON dataset is always flagged "Invalid" to indicate the following:
  - Router reload
  - Interface module reload
  - New circuit creation
  - SSO
  - After the **clear counters** command resets the PMON data

  It's expected behaviour. After the first Near End PMON dataset, the subsequent Near End datasets are never flagged "Invalid."
- If there's an occurrence of an alarm at the Near End, the Far End PMON dataset is flagged "Invalid".

Note The Far End "Invalid" flag attribute is supported for line, section, path, and VT level alarms. It's not supported for T1, T3, E1, and E3 level alarms.

```
Router#show controller sts1e 0/2/14
STS1E 0/2/14 is down.
  Hardware is NCS4200-3GMS

 Port configured rate: OC1
 Applique type is Channelized STS1E
 Clock Source is Internal
Medium info:
  Type: STS1E, Line Coding: NRZ,
 Alarm Throttling: OFF
 SECTION:
  LOS = 1          LOF = 0                          BIP(B1) = 18

STS1E Section Tables
  INTERVAL       CV-S    ES-S   SES-S  SEFS-S
  00:47-01:01       0     116     116     116
  00:32-00:47       0       0       0       0
  00:17-00:32       0       1       1       1  (Invalid)
Total of Data in Current and Previous Intervals
                    0     117     117     117  (Invalid)


LINE:
  AIS = 0          RDI = 0          REI = 41         BIP(B2) = 6
Active Defects: None
Detected Alarms: SLOS
Asserted/Active Alarms: SLOS
Alarm reporting enabled for: SLOS SLOF LAIS SF SD LRDI B1-TCA B2-TCA
BER thresholds:  SF = 10e-3  SD = 10e-6
TCA thresholds:  B1 = 10e-6  B2 = 10e-6
Rx: S1S0 = NA
    J0 = 00

    RX S1 = FF

Tx: S1S0 = NA
    J0 = 04

Tx J0 Length : 64
Tx J0 Trace :

  52 6F 75 74 65 72 20 20 20 20 20 20 20 20 20 20     Router
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 00 00                   ..

Expected J0 Length : 64
Expected J0 Trace :

  52 6F 75 74 65 72 20 20 20 20 20 20 20 20 20 20     Router
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 00 00                   ..

Rx J0 Length : 64
Rx J0 Trace :
```

```
  52 6F 75 74 65 72 20 20 20 20 20 20 20 20 20 20     Router
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 0D 00                   ..

STS1E Line Tables
  INTERVAL     CV-L  ES-L  SES-L  UAS-L  CV-LFE  ES-LFE  SES-LFE  UAS-LFE
  00:47-01:01     0     0      0    118       0       0        0        0  (FE Invalid)
  00:32-00:47     0     0      0      0       0       0        0        0
  00:17-00:32     0     1      1      0       0       0        0        0  (NE, FE Invalid)
Total of Data in Current and Previous Intervals
                  0     1      1    118       0       0        0        0  (NE, FE Invalid)



PATH 1:
Clock Source is internal

  AIS = 0          RDI = 0          REI = 12         BIP(B3) = 131
  LOM = 0          PLM = 0          UNEQ = 0          LOP = 0

Active Defects: None
Detected Alarms: PAIS
Asserted/Active Alarms: None
Alarm reporting enabled for: PAIS PRDI PUNEQ PLOP PPLM LOM B3-SF B3-SD B3-TCA

BER threshold:  SF = 10e-3  SD = 10e-6
TCA threshold:  B3 = 10e-6
Rx: C2 = FF
Tx: C2 = 02

Tx J1 Length : 64
Tx J1 Trace

  52 6F 75 74 65 72 20 30 2F 32 2F 31 34 2E 31 00     Router 0/2/14.1.
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

Expected J1 Length : 64
Expected J1 Trace

  52 6F 75 74 65 72 20 30 2F 32 2F 31 34 2E 31 00     Router 0/2/14.1.
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

Rx J1 Length : 64
Rx J1 Trace

  52 6F 75 74 65 72 20 30 2F 32 2F 31 34 2E 31 00     Router 0/2/14.1.
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

SONET Path Tables
  INTERVAL     CV-P  ES-P  SES-P  UAS-P  CV-PFE  ES-PFE  SES-PFE  UAS-PFE
  00:47-01:01     0     0      0    120       0       0        0        0  (FE Invalid)
  00:32-00:47     0     0      0      0       0       0        0        0
  00:17-00:32     0     1      1      0       0       0        0        0  (NE, FE Invalid)
Total of Data in Current and Previous Intervals
                  0     1      1    120       0       0        0        0  (NE, FE Invalid)
```

```
STS1E 0/2/14.1 PATH  is down.
  Hardware is NCS4200-3GMS

 Applique type is VT1.5

 STS-1 1, VTG 1, VT 1 (STS1E 0/2/14.1/1/1 VT) is down
 VT Receiver has LP_AIS.
  cep is configured: FALSE cem_id  (0)
  fwd_alarm_ais :0    fwd_alarm_rai :0, Clock Source is Internal
  BIP2-tca:6, BIP2-sf:3, BIP2-sd:6
  Tx V5:2
  Rx V5:2
  Tx J2 Length=64
  TX J2 Trace Buffer:
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

  Expected J2 Length=64
  Expected J2 Trace Buffer:
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

  Rx J2 Length=16
  RX J2 Trace Buffer:
  CRC-7: 0xD8 OK

  61 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     a...............

 INTERVAL     CV-V  ES-V  SES-V  UAS-V  CV-VFE  ES-VFE  SES-VFE  UAS-VFE
 00:47-01:01     0     0      0    122       0       0        0        0  (FE Invalid)
 00:32-00:47     0     0      0      0       0       0        0        0
 00:17-00:32     3     1      0      0       3       1        1        0  (NE,FE Invalid)
 Total           3     1      0    122       1       0        3        0  (NE, FE Invalid)

 STS-1 1, VTG 1, T1 1 (STS1E 0/2/14.1/1/1 T1) is down
  FDL per AT&T 54016 spec.
  Receiver is getting AIS.
  Framing is ESF, Clock Source is Internal
  Near End Data
  INTERVAL     CV-L   ES-L   CV-P   ES-P  SES-P  CSS-P  SAS-P  UAS-P   FC-P
  00:47-01:01     0      0      0      0      0      0      0    866      0
  00:32-00:47     0      0      0      0      0      0      0    900      0
  00:17-00:32     0      0      0      1      1      0      1    895      1  (Invalid)
  Total           0      0      0      1      1      0      1   2661      1  (Invalid)
  Far End Data
  INTERVAL     ES-LFE  ES-PFE  SES-PFE  SEFS-PFE  CSS-PFE  UAS-PFE  FC-PFE
  00:47-01:01       0       0        0         0        0        0       0  (Invalid)
  00:32-00:47       0       0        0         0        0        0       0
  00:17-00:32       0       4        4         2        0        0       0  (Invalid)
  Total             0       4        4         2        0        0       0  (Invalid)
```

Configuring Port Rate and Verifying Pluggables

A comprehensive range of pluggable optical modules is available. For more information, see *Cisco ASR 900 Series - Supported Optics*.

Configuring Port Rate for SONET

To configure port rate for SONET, use the following commands:

```
enable
configure terminal
controller mediatype 0/0/16
mode sonet
exit
controller sonet 0/0/16
rate oc3
```

Verifying the Pluggables

Before you configure the pluggables, use the following commands to verify the supported plugables:

show hw-module subslot <slot/bay> transceiver <port> status:

```
The Transceiver in slot 0 subslot 7 port 4 is enabled.
  Module temperature                          = +46.636 C
  Transceiver Tx supply voltage               = 3291.5 mVolts
  Transceiver Tx bias current                 = 17264 uAmps
  Transceiver Tx power                        = -2.9 dBm
  Transceiver Rx optical power                = -7.4 dBm
```



Note The **show hw-module subslot <slot/bay> transceiver <port> status** displays as **Enabled** if the pluggables are supported and the command displays as **Disabled** if the pluggables are not supported.

show hw-module subslot <slot/bay> transceiver <port> idprom:

```
show hw-module subslot 0/7 transceiver 6 idprom detail
IDPROM for transceiver SPA-1T8S-10CS_7/6:
  Description                                 = SFP or SFP+ optics (type 3)
  Transceiver Type:                           = ONS SE Z1 (406)
  Product Identifier (PID)                    = ONS-SE-Z1
  Vendor Revision                             = A
  Serial Number (SN)                          = FNS19251NPM
  Vendor Name                                 = CISCO-FINISAR
  Vendor OUI (IEEE company ID)                = 00.90.65 (36965)
  CLEI code                                   = WMOTCZPAAA
  Cisco part number                           = 10-1971-04
  Device State                                = Enabled.
  Date code (yy/mm/dd)                        = 15/06/19
  Connector type                              = LC.
  Encoding                                    = 8B10B
                                                NRZ
                                                Manchester
  Nominal bitrate                             = OC48/STM16 (2500 Mbits/s)
  Minimum bit rate as % of nominal bit rate = not specified
  Maximum bit rate as % of nominal bit rate = not specified
  The transceiver type is 406
  Link reach for 9u fiber (km)                = IR-1(15km) (15)
  Link reach for 50u fiber (m)                = SR(2km) (0)
                                                IR-1(15km) (0)
                                                IR-2(40km) (0)
                                                LR-1(40km) (0)
                                                LR-2(80km) (0)
                                                LR-3(80km) (0)
                                                DX(40KM) (0)
```

```
                                          HX(40km) (0)
                                          ZX(80km) (0)
                                          VX(100km) (0)
                                          1xFC, 2xFC-SM(10km) (0)
                                          ESCON-SM(20km) (0)
  Link reach for 62.5u fiber (m)        = SR(2km) (0)
                                          IR-1(15km) (0)
                                          IR-2(40km) (0)
                                          LR-1(40km) (0)
                                          LR-2(80km) (0)
                                          LR-3(80km) (0)
                                          DX(40KM) (0)
                                          HX(40km) (0)
                                          ZX(80km) (0)
                                          VX(100km) (0)
                                          1xFC, 2xFC-SM(10km) (0)
                                          ESCON-SM(20km) (0)
  Nominal laser wavelength              = 1310 nm.
  DWDM wavelength fraction              = 1310.0  nm.
  Supported options                     = Tx disable
                                          Tx fault signal
                                          Loss of signal (standard implementation)
  Supported enhanced options            = Alarms for monitored parameters
                                          Software Rx LOS monitoring
  Diagnostic monitoring                 = Digital diagnostics supported
                                          Diagnostics are externally calibrated
                                          Rx power measured is "Average power"
  Transceiver temperature operating range = -40 C to 85 C (industrial)
  Minimum operating temperature         = -40 C
  Maximum operating temperature         = 85 C
  High temperature alarm threshold      = +90.000 C
  High temperature warning threshold    = +85.000 C
  Low temperature warning threshold     =  -40.000 C
  Low temperature alarm threshold       =  -45.000 C
  High voltage alarm threshold          = 3630.0 mVolts
  High voltage warning threshold        = 3470.0 mVolts
  Low voltage warning threshold         = 3140.0 mVolts
  Low voltage alarm threshold           = 2971.2 mVolts
  High laser bias current alarm threshold   = 85.000 mAmps
  High laser bias current warning threshold = 65.000 mAmps
  Low laser bias current warning threshold  = 4.000 mAmps
  Low laser bias current alarm threshold    = 2.000 mAmps
  High transmit power alarm threshold       =  4.0 dBm
  High transmit power warning threshold     =  2.0 dBm
  Low transmit power warning threshold      = -7.0 dBm
  Low transmit power alarm threshold        = -9.0 dBm
  High receive power alarm threshold        =  1.0 dBm
  Low receive power alarm threshold        = -26.0 dBm
  High receive power warning threshold        = -1.0 dBm
  Low receive power warning threshold       = -24.9 dBm
  External Calibration: bias current slope  = 1.000
  External Calibration: bias current offset = 0
```

show hw-module subslot <slot/bay> transceiver <port> idprom brief:

```
sh hw-module subslot 0/7 transceiver 6 idprom brief
IDPROM for transceiver SPA-1T8S-10CS_7/6:
  Description                           = SFP or SFP+ optics (type 3)
  Transceiver Type:                     = ONS SE Z1 (406)
  Product Identifier (PID)              = ONS-SE-Z1
  Vendor Revision                       = A
  Serial Number (SN)                    = FNS19251NQ0
  Vendor Name                           = CISCO-FINISAR
  Vendor OUI (IEEE company ID)          = 00.90.65 (36965)
  CLEI code                             = WMOTCZPAAA
```

```
Cisco part number                          = 10-1971-04
Device State                               = Enabled.
Date code (yy/mm/dd)                       = 15/06/19
Connector type                             = LC.
Encoding                                   = 8B10B
                                             NRZ
                                             Manchester
Nominal bitrate                            = OC48/STM16 (2500 Mbits/s)
Minimum bit rate as % of nominal bit rate = not specified
Maximum bit rate as % of nominal bit rate = not specified
```

Loopback Remote on T1 and T3 Interfaces

The remote loopback configuration attempts to put the far-end T1 or T3 into a loopback.

The remote loopback setting loops back the far-end at line or payload, using IBOC (inband bit-orientated CDE) or the ESF loopback codes to communicate the request to the far-end.

Restrictions for Loopback Remote

- E1 and E3 loopback remote are not supported until Cisco IOS XE Fuji 16.9.4 release. Starting from Cisco IOS XE Fuji 16.9.5 release, E1 and E3 loopback remote are supported.
- IBOC loopcode configuration is not supported when CESoP or SATOP (framed or unframed) is configured.
- ESF loopcode configuration is not supported when SAToP is configured.

Configuring Loopback Remote in Sonet

To set T1 loopback remote iboc fac1/fac2/csu for OCX sonet, perform the following tasks in global configuration mode:

```
enable
configure terminal
controller sonet 0/0/1
mode ct3
t1 1 loopback remote iboc {fac1 | fac2 | csu}
mode vt-15
vtg 1 t1 1 loopback remote iboc {fac1 | fac2 | csu}
```

To set T1 loopback remote iboc esf line csu/esf payload for OCX sonet, perform the following tasks in global configuration mode:

```
enable
configure terminal
controller sonet 0/0/1
mode ct3
t1 1 loopback remote iboc esf {line csu | payload}
mode vt-15
vtg 1 t1 1 loopback remote esf {line csu | payload}
```

To set T3 loopback remote line/payload for OCX in sonet, perform the following tasks in global configuration mode:

```
enable
configure terminal
controller sonet 0/0/1
mode t3
t3 loopback remote {line | payload}
```



Note **loopback remote esf line niu** is not supported.

Verifying the Loopback Remote Configuration

Use the following command to check the T1 loopback remote configuration:

```
router# show run | sec 0/0/1
controller SONET 0/0/1
rate OC3
no ais-shut
alarm-report all
clock source internal
!
sts-1 1
!
sts-1 2
  clock source internal
  mode ct3
  t3 framing c-bit
  t3 clock source internal
  t1 1 Loopback remote iboc fac1
  t1 1 framing SF
```

Use the following command to verify the T1 loopback remote configuration:

```
Router(config-ctrlr-sts1)# show controller sonet 0/0/1 | b STS-1 2, T1 1
 STS-1 2, T1 1 (CT3 2-1) is up
  timeslots:
  Configured for NIU FAC1 Line Loopback with IBOC
  Currently in Inband Remotely Line Looped
  Receiver has no alarms.
  Framing is SF, Clock Source is Internal
```

Use the following command to check T3 loopback remote configuration:

```
Router# show run | sec 0/0/1
controller SONET 0/0/1
rate OC3
no ais-shut
alarm-report all
clock source internal
!
sts-1 1
!
sts-1 2
!
sts-1 3
  clock source internal
  mode t3
  t3 framing c-bit
  t3 loop remote line
```

```
  t3 clock source internal
```

Use the following command to verify T3 loopback remote configuration:

```
Router(config-ctrlr-sts1)# do show controller sonet 0/0/1 | b Path 3
OC3.STS1 0/0/1 Path 3 is up. (Configured for Remotely Looped)
  Currently in Remotely Line Looped
  Hardware is NCS4200-1T8S-10CS

  Applique type is T3
  Receiver has no alarms.
  MDL transmission is disabled
```

Configuring POS Scrambling

Scrambling is designed to randomize the pattern of 1s and 0s carried in the physical layer frame. Randomizing the digital bits can prevent continuous, non-variable bit patterns. SONET payload scrambling applies a self-synchronous scrambler to the Synchronous Payload Envelope (SPE) of the interface to ensure sufficient bit transition density. You can enable or disable SONET payload scrambling on a concatenated serial interface (POS).

To configure SONET controller, enter the following commands:

```
Router(config)#controller media 0/4/3
Router(config-controller)#mode sonet
Router(config-controller)#controller sonet 0/4/3
Router(config-controller)#rate oc3
Router(config-controller)#sts
Router(config-controller)#sts 1 - 3 mode sts-3c
Router(config-ctrlr-sts3c)#channel-group 0
Router(config-ctrlr-sts3c)#end
```

To enable scrambling on a serial interface for the SONET controller, enter the following commands:

```
Router(config)#interface Serial0/4/3.1
Router(config-if)#pos scramble
Router(config-if)#end
```

To disable scrambling on a serial interface for the SONET controller, enter the following commands:

```
Router(config)#interface Serial0/4/3.1
Router(config-if)#no pos scramble
Router(config-if)#end
```

Verifying POS Scrambling

Use the following commands to verify the POS scrambling configuration:

```
Router#show ip interface brief
Interface              IP-Address      OK? Method Status                Protocol
GigabitEthernet0/0/0   unassigned      YES unset  down                  down
GigabitEthernet0/0/1   unassigned      YES unset  down                  down
GigabitEthernet0/0/2   unassigned      YES unset  down                  down
GigabitEthernet0/0/3   unassigned      YES unset  up                    up
GigabitEthernet0/0/4   unassigned      YES unset  down                  down
```

```
GigabitEthernet0/0/5   unassigned      YES unset  down                  down
GigabitEthernet0/0/6   unassigned      YES unset  down                  down
GigabitEthernet0/0/7   unassigned      YES unset  down                  down
GigabitEthernet0/5/0   unassigned      YES unset  up                    up
GigabitEthernet0/5/1   unassigned      YES unset  down                  down
GigabitEthernet0/5/2   unassigned      YES unset  down                  down
GigabitEthernet0/5/3   unassigned      YES unset  down                  down
GigabitEthernet0/5/4   unassigned      YES unset  down                  down
GigabitEthernet0/5/5   unassigned      YES unset  down                  down
GigabitEthernet0/5/6   unassigned      YES unset  down                  down
GigabitEthernet0/5/7   unassigned      YES unset  down                  down
GigabitEthernet0       7.19.26.14      YES manual up                    up
Serial0/4/3.1          30.30.30.1      YES manual up                    up
```

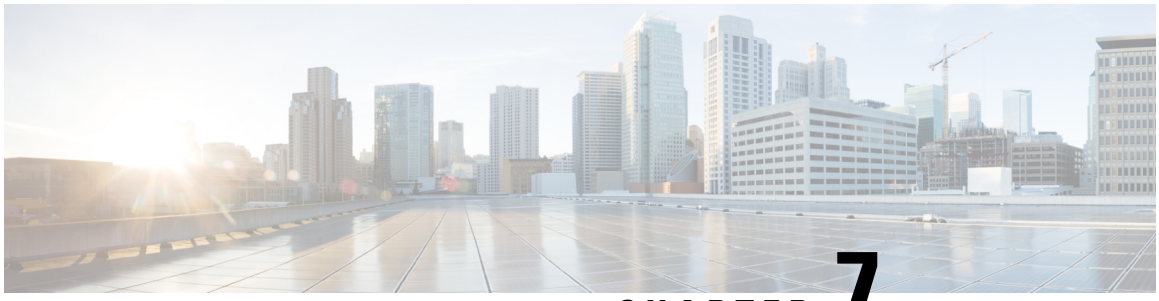
Associated Commands

The following table shows the Associated Commands for SONET configuration:

Commands	Links
ais-shut	http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/interface/command/ir-cr-book/ir-a1.html#wp7654966010
alarm-report	http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/interface/command/ir-cr-book/ir-a1.html#wp2800999060
aps adm	http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/interface/command/ir-cr-book/ir-a1.html#wp8015117230
aps group	http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/interface/command/ir-cr-book/ir-a1.html#wp1674734739
aps protect	http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/interface/command/ir-cr-book/ir-a1.html#wp2073867702
aps revert	http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/interface/command/ir-cr-book/ir-a1.html#wp4063780600
aps unidirectional	http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/interface/command/ir-cr-book/ir-a1.html#wp5340799170
aps working	http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/interface/command/ir-cr-book/ir-a1.html#wp8949584630
cem-group *cem-group-number* **cep**	http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/interface/command/ir-cr-book/ir-c1.html#wp2440628600

Commands	Links
controller mediatype	http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/interface/command/ir-cr-book/ir-c2.html#wp1201337639
controller protection-group	http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/mcl/allreleasemcl/all-book/all-03.html
controller sonet	http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/interface/command/ir-cr-book/ir-c2.html#wp2020468554
clock source	http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/interface/command/ir-cr-book/ir-c2.html#wp3604380959
loopback	http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/interface/command/ir-cr-book/ir-l2.html#wp2735045490
mode sonet	http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/interface/command/ir-cr-book/ir-l2.html#wp2327088950
mode sts-nc	http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/interface/command/ir-cr-book/ir-l2.html#wp1791424945
mode vt-15	http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/interface/command/ir-cr-book/ir-l2.html#wp1137973905
overhead c2	http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/interface/command/ir-cr-book/ir-o1.html#wp1973678817
overhead j0	http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/interface/command/ir-cr-book/ir-o1.html#wp4338698890
overhead j1	http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/interface/command/ir-cr-book/ir-o1.html#wp1987243836
overhead s1s0	http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/interface/command/ir-cr-book/ir-o1.html#wp2779929239
protection-group	http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/mcl/allreleasemcl/all-book/all-10.html
protection-group [**working** | **protect**]	http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/mcl/allreleasemcl/all-book/all-10.html
rate [**OC3** | **OC12** | **OC48** | **OC192**]	http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/interface/command/ir-cr-book/ir-o1.html#wp4442889730

Commands	Links
shutdown	http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/interface/command/ir-cr-book/ir-s6.html#wp3364503641
show controllers sonet	http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/interface/command/ir-cr-book/ir-s3.html#wp1341372847
show hw-module subslot transceiver	http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/interface/command/ir-cr-book/ir-s4.html#wp6553420000
show protection-group	http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/mcl/allreleasemcl/all-book/all-14.html
sts-1	http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/interface/command/ir-cr-book/ir-s6.html#wp2423232697
t1 *t1-line-number* **framing**	http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/interface/command/ir-cr-book/ir-t1.html#wp2623191253
t1 *t1-line-number* **clock source**	http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/interface/command/ir-cr-book/ir-t1.html#wp3480850667
threshold	http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/interface/command/ir-cr-book/ir-t1.html#wp2311589330
type sts48c	http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/mcl/allreleasemcl/all-book/all-15.html
vtg *vtg-line-number* **t1** *t1-line-number* **loopback**	http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/interface/command/ir-cr-book/ir-t2.html#wp3494199143



CHAPTER 7

Configuring SDH

SDH is a standard that defines optical signals as well as a synchronous frame structure for multiplexed digital traffic. It is is used in Europe by the International Telecommunication Union Telecommunication Standardization Sector (ITU-T). The SDH equipment is used everywhere except North America. The IM supports the entire SDH hierarchy (except VC-2/C-2).

- Overview of SDH, on page 81
- Services Provided by SDH Configuration, on page 83
- SDH Multiplexing, on page 85
- Configuring AU-4 — TUG-3 — TUG-2 — VC-12 for Framed SAToP, on page 96
- Configuring AU-3 — TUG-2 — VC-11 — T1 for Framed SAToP, on page 97
- Verifying SDH Configuration for Framed SAToP, on page 97
- Restrictions for SDH, on page 98
- Configuring Mediatype Controller, on page 99
- Configuring Rate on SDH Ports, on page 99
- SDH Line and Section Configuration Parameters, on page 100
- Configuring BERT in SDH for SAToP, on page 118
- SDH T1/E1 Configuration Parameters, on page 122
- SDH T3/E3 Configuration Parameters, on page 123
- SDH VC Configuration Parameters for SAToP, on page 124
- Configuring ACR on SDH, on page 126
- Configuring DCR on SDH, on page 127
- Loopback Remote on T1 and T3 Interfaces, on page 128
- Performance Monitoring Use Cases or Deployment Scenarios for SDH, on page 132

Overview of SDH

SDH was defined by European Telecommunications Standards Institute (ETSI) and is now being controlled by the ITU-T standards body. SDH standard is prevalently used everywhere outside North America and Japan.

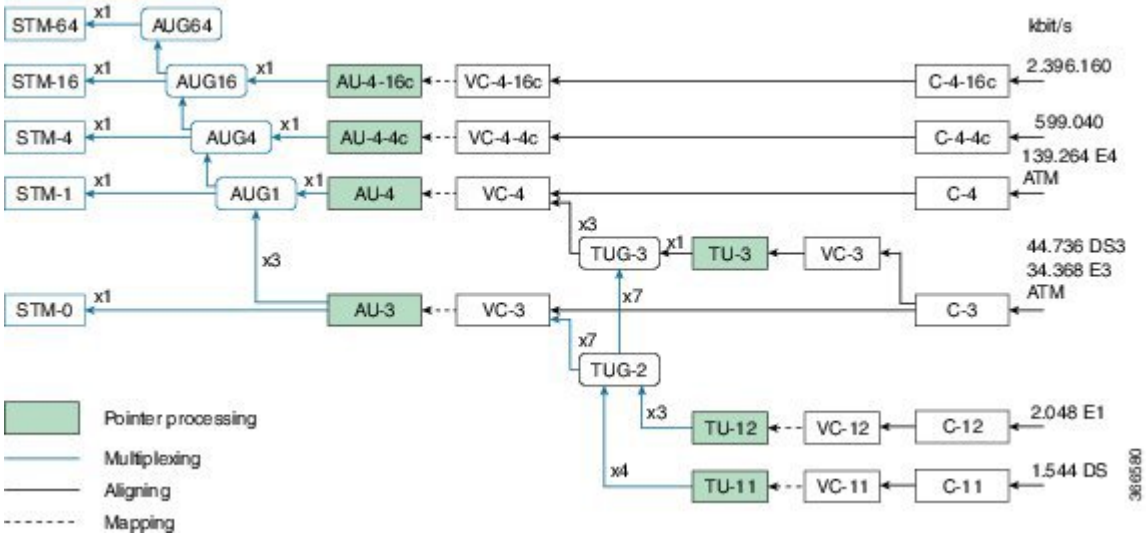
The following are true for SDH:

- Network Node Interface (NNI) defined by CCITT/ITU-TS for worldwide use and partly aompatible with SONET
- One of the two options for the User-Network Interface (UNI) (the customer connection) and formally the U reference point interface for support of BISDN

Basic SDH Signal

The basic format of an SDH signal allows it to carry many different services in its VC because SDH signal is bandwidth-flexible. This capability allows the transmission of high-speed packet-switched services, ATM, contribution video, and distribution video. However, SDH still permits transport and networking at the 2 Mbit/s, 34 Mbit/s, and 140 Mbit/s levels, accommodating the existing digital hierarchy signals. In addition, SDH supports the transport of signals based on the 1.5 Mbit/s hierarchy.

SDH Hierarchy



Modes of CEM

- **Structure Agnostic TDM over Packet (SAToP)** (RFC 4553) – SAToP mode is used to encapsulate T1/E1 or T3/E3 unstructured (unchannelized) services over packet switched networks. In SAToP mode, the bytes are sent out as they arrive on the TDM line. Bytes do not have to be aligned with any framing.

  In this mode, the interface is considered as a continuous framed bit stream. The packetization of the stream is done according to IETF RFC 4553. All signaling is carried transparently as a part of a bit stream.

- **Circuit Emulation Service over Packet (CEP)** (RFC 4842) - CEP mode is used to encapsulate SDH payload envelopes (SPEs) like VC11, VC12, VC4, or VC4-Nc over PSN. In this mode, the bytes from the corresponding SPE are sent out as they arrive on the TDM line. The interface is considered as a continuous framed bit stream. The packetization of the stream is done according to IETF RFC 4842.

Table 13: SDH CEM Channelization Modes

SDH Modes	CEM	Ports
VC4-16c	CEP	STM16
VC4-4c	CEP	STM4, STM16
VC4	CEP	STM1, STM4, STM16

SDH Modes	CEM	Ports
TUG-3-E3	SAToP	STM1, STM4, STM16
TUG-3-T3	SAToP	STM1, STM4, STM16
TUG-2-VC11	CEP	STM1, STM4, STM16
TUG-2-VC12	CEP	STM1, STM4, STM16
TUG-2-T1	SAToP	STM1, STM4, STM16
TUG-2-E1	SAToP	STM1, STM4, STM16

Services Provided by SDH Configuration

The following services are provided by SDH Configuration:

SDH Circuits	Configuration Details
Configuring VC4 CEP circuit	• *Configuring Mediatype Controller* • *Configuring Rate on SDH Ports* • *Configurin AU-3 or AU-4 Mapping* • *Configuring Modes under AU-4 Mapping* • *Configuring Mode VC4 CEP*
Configuring VC4-4c circuit or Configuring VC4-16c circuit	• *Configuring Mediatype Controller* • *Configuring Rate on SDH Ports* • *Configuring AU-3 or AU-4 Mapping* • *Configuring Modes under AU-4 Mapping* • *Configuring Mode VC-4 Nc*
Configuring VC4—TUG3—E3 circuit	• *Configuring Mediatype Controller* • *Configuring Rate on SDH Ports* • *Configuring AU-3 or AU-4 Mapping* • *Configuring Mode TUG-3*

SDH Circuits	Configuration Details
Configuring VC4—TUG3—T3 circuit	• *Configuring Mediatype Controller* • *Configuring Rate on SDH Ports* • *Configuring AU-3 or AU-4 Mapping* • *Configuring Mode TUG-3* • *Configuring AU-4—TUG-3—VC-3—DS3*
Configuring VC4—TUG-3—TUG-2—VC-12 circuit	• *Configuring Mediatype Controller* • *Configuring Rate on SDH Ports* • *Configuring AU-3 or AU-4 Mapping* • *Configuring Mode TUG-3* • *Configuring VC4—TUG-3—TUG-2—VC-12—VC*
Configuring VC4 — TUG-3 — TUG-2 — VC-12 — E1 circuit	• *Configuring Mediatype Controller* • *Configuring Rate on SDH Ports* • *Configuring AU-3 or AU-4 Mapping* • *Configuring Mode TUG-3* • *Configuring AU-4—TUG-3—TUG-2—VC-12*
Configuring VC4— TUG-3—TUG-2—VC-11 circuit	• *Configuring Mediatype Controller* • *Configuring Rate on SDH Ports* • *Configuring AU-3 or AU-4 Mapping* • *Configuring Mode TUG-3* • *Configuring AU-4—VC4—TUG-3—TUG-2—VC-11—T1*
Configuring AU-3—VC-3—E3 circuit	• *Configuring Mediatype Controller* • *Configuring Rate on SDH Ports* • *Configuring AU-3 or AU-4 Mapping* • *Configuring AU-3—VC-3—E3*

SDH Circuits	Configuration Details
Configuring AU-3—VC-3—DS3 circuit	• *Configuring Mediatype Controller* • *Configuring Rate on SDH Ports* • *Configuring AU-3 or AU-4 Mapping* • *Configuring AU-3—VC-3—DS3 circuit*
Configuring (AU-3) VC-3—TUG-2—VC-12—T1 circuit	• *Configuring Mediatype Controller* • *Configuring Rate on SDH Ports* • *Configuring AU-3 or AU-4 Mapping* • *Configuring Mode VC-1x* • *Configuring AU-3—TUG-2—VC-11—T1*
Configuring (AU-3) VC-3—TUG-2—VC-12 circuit	• *Configuring Mediatype Controller* • *Configuring Rate on SDH Ports* • *Configuring AU-3 or AU-4 Mapping* • *Configuring Mode VC-1x* • *Configuring AU-3—TUG-2—VC-12—E1*
Configuring (AU-3) VC-3—TUG-2—VC11 circuit	• *Configuring Mediatype Controller* • *Configuring Rate on SDH Ports* • *Configuring AU-3 or AU-4 Mapping* • *Configuring Mode VC-1x* • *Configuring AU-3—TUG-2—VC-11—T1*
Configuring (AU-3) VC-3—TUG-2—VC11—E1 circuit	• *Configuring Mediatype Controller* • *Configuring Rate on SDH Ports* • *Configuring AU-3 or AU-4 Mapping* • *Configuring Mode VC-1x* • *Configuring AU-3—TUG-2—VC-12—E1*

SDH Multiplexing

The terms and definitions of SDH multiplexing principles are:

- **Mapping** – A process used when tributaries are adapted into VCs by adding justification bits and Path Overhead (POH) information.
- **Aligning** – This process takes place when a pointer is included in a Tributary Unit (TU) or an Administrative Unit (AU), to allow the first byte of the VC to be located.
- **Multiplexing** – This process is used when multiple lower-order path layer signals are adapted into a higher-order path signal, or when the higher-order path signals are adapted into a Multiplex Section.
- **Stuffing** – As the tributary signals are multiplexed and aligned, some spare capacity is designed into the SDH frame to provide enough space for all the various tributary rates. Therefore, at certain points in the multiplexing hierarchy, this space capacity is filled with "fixed stuffing" bits that carry no information, but are required to fill up the particular frame.

Modes of SDH

A Synchronous Transport Module (STM) signal is the Synchronous Digital Hierarchy (SDH) equivalent of the SONET STS. In this document, STM term refers to both path widths and optical line rates. The paths within an STM signals are called administrative units (AUs).

An AU is the information structure that provides adaptation between the higher-order path layer and the multiplex section layer. It consists of an information payload (the higher-order VC) and an AU pointer, which indicates the offset of the payload frame start relative to the multiplex section frame start.

The AU-3 pointer is composed of 3 bytes; the AU-4 pointer is composed of 9 bytes.

The payload of the STM-1 frame consists of one AU-4 unit or three AU-3 units.

Augment Mapping

An administrative unit group (AUG) consists of one or more administrative units occupying fixed, defined positions in an STM payload. Augment mapping is supported at STM1 level.The following types of augment mapping are supported:

- Augment Mapping AU-4

Note This is the default augment mapping mode.

- Augment Mapping AU-3
- Mixed (AU-3 and AU-4) Augment Mapping

The supported modes of SDH are:

- AU-4-16c (VC4-16c)
- AU-4-4c (VC4-4c)
- AU-4 (VC4)
- AU-4 — TUG-3 — VC-3 — DS3
- AU-4 — TUG-3 — VC-3 — E3
- AU-4 — TUG-3 — TUG-2 — VC-11 — T1

- AU-4 — TUG-3 — TUG-2 — VC-12 — E1
- AU-4 — TUG-3 — TUG-2 — VC-11
- AU-4 — TUG-3 — TUG-2 — VC-12
- AU-3 — VC-3 — DS3
- AU-3 — TUG-2 — VC-11 — T1
- AU-3 — TUG-2 — VC-12 — E1
- AU-3 — TUG-2 — VC-11
- AU-3 — TUG-2 — VC-12
- AU-3 — VC-3 — E3

Configuring AUG Mapping

This section describes the configuration of Administration Units Group (AUG) mapping.

Configuring AU-3 or AU-4 Mapping

To configure AU-3 or AU-4 mapping:

```
configure terminal
aug mapping [au-3 | au-4]
end
```

Note The **aug mapping** command is available only when SDH framing is configured.

Note The AUG mapping mode is AU-4 by default. AUG mapping is supported at STM-1 level.

Configuring Mixed AU-3 and AU-4 Mapping

To configure mixed AU-3 and AU-4 mapping:

```
configure terminal
aug mapping [au-3 | au-4] stm [1-1] stm1 number [1-4]
end
```

Note Use the following command to change the AUG mapping of a particular STM-1 to AU-3:

aug mapping *au-3* **stm** [*1-16*] *path number 1-16*

After configuring this command for STM-4 the AUG mapping of path 2, 3, and 4 is AU-4 and for path 1 it is AU-3.

Verifying AUG Mapping Configuration

Use **show running-configuration** command to verify the AUG mapping configuration.

```
show running-config | sec 0/3/4
PDT: %SYS-5-CONFIG_I: Configured from console by console
controller MediaType 0/0/16
mode sdh
controller SDH 0/0/16
rate STM4
no ais-shut
alarm-report all
threshold sf-ber 3
clock source internal
overhead s1s0 0
aug mapping au-4 stm 1
aug mapping au-3 stm 2
aug mapping au-4 stm 3
aug mapping au-4 stm 4
au-4 1
!
au-3 4
!
au-3 5
!
au-3 6
!au-4 3
!au-4 4
!
```

Configuring Modes under AU-4 Mapping

This section describes the configuration of modes under AU-4 mapping.

Configuring Mode VC-4 CEP

To configure mode VC-4 CEP:

```
enable
configure terminal
controller sdh 0/0/16
rate stm 4
aug mapping au-4
au-4 1
mode vc4
cem-group 100 cep
end
```

Note Overhead C2 should match with the peer end else it will result in PPLM alarm.

Verifying Mode VC-4 Configuration

Use the **show running-configuration** command to verify the mode VC-4 configuration.

```
#show running-config | sec 0/3/4
PDT: %SYS-5-CONFIG_I: Configured from console by console
platform enable
controller MediaType 0/0/16 oc12
```

```
controller MediaType 0/0/16
mode sdh
controller SDH 0/0/16
rate STM4
no ais-shut
alarm-report all
threshold sf-ber 3
clock source internal
overhead s1s0 0
aug mapping au-4
au-4 1
mode vc4
clock source internal
au-4 2
!
au-4 3
!
au-4 4
```

Configuring Mode TUG-3

To configure mode TUG-3:

```
enable
configure terminal
controller sdh 0/0/16
rate stm4
au-4 1
mode tug-3
end
```

Note Mode TUG-3 creates three TUG-3 paths. TUG-3 range is 1 to 3.

Configuring AU-4 — TUG-3 — VC-3 — DS3

To configure AU-4 — TUG-3 — VC-3 — DS3:

```
enable
configure terminal
controller sdh 0/0/16
rate stm4
au-4 1
mode tug-3
tug-3 1
mode t3
cem-group 100 unframed
end
```

Verifying DS3 Configuration

Use **show running-configuration** command to verify DS3 configuration:

```
#show running-configuration | sec 0/3/4
platform enable controller MediaType 0/0/16 oc12
controller MediaType 0/0/16
mode sdh
controller SDH 0/0/16
rate STM4
no ais-shut
alarm-report all
```

```
threshold sf-ber 3
clock source internal
overhead s1s0 0
aug mapping au-4
au-4 1
mode tug-3
clock source internal
tug-3 1mode T3
t3 clock source internal
t3 framing c-bit
!
tug-3 2
!
tug-3 3
!
au-4 2
!
au-4 3
!
au-4 4
```

Configuring AU-4 — TUG-3 — VC-3 — E3

To configure AU-4 — TUG-3 — VC-3 — E3:

```
enable
configure terminal
controller sdh 0/0/16
rate stm4
au-4 1
mode tug-3
tug-3 1
mode e3
cem-group 100 unframed
end
```

Verifying E3 Configuration

Use **show running-configuration** command to verify E3 configuration.

```
#show running-configuration | sec 0/0/16
platform enable
controller MediaType 0/0/16 oc12
controller MediaType 0/0/16
mode sdh
controller SDH 0/0/16
rate STM4
no ais-shut
alarm-report all
threshold sf-ber 3
clock source internal
overhead s1s0 0
aug mapping au-4
au-4 1
mode tug-3
clock source internal
tug-3 1
mode E3
e3 clock source internal
e3 framing g751
!
tug-3 2
!
tug-3 3
```

```
!
au-4 2
```

Configuring Mode VC-1x

To configure mode VC-1x:

```
enable
configure terminal
controller sdh 0/0/16
rate stm1
no ais-shut
alarm-report all
clock source internal
overhead s1s0 0
aug mapping au-4
au-4 1
clock source internal
mode tug-3
tug-3 1
mode VC1x
tug-2 1 payload VC11
tug-2 2 payload VC11
tug-2 3 payload VC11
tug-2 4 payload VC11
tug-2 5 payload VC11
tug-2 6 payload VC11
tug-2 7 payload VC11
end
```



Note When you configure mode VC-1x, seven TUG-2 payloads are created. TUG-2 payloads can be of two types, VC-11 and VC-12. Default for TUG-2 payload mode is VC-11.

TUG-2 payload VC-11 can be configured as VC or T1 and the range is 1 to 4.

TUG-2 payload VC-12 can be configured as VC or E1 and the range is 1 to 3.

Configuring AU-4 — TUG-3 — TUG-2 — VC-11 — T1

To configure AU-4 — TUG-3 — TUG-2 — VC-11 — T1:

```
enable
configure terminal
controller sdh 0/0/16
rate stm4
au-4 1
mode tug-3
tug-3 1
mode vc1x
tug-2 1 payload vc11
t1 1 cem-group 10 unframed
vc 1 overhead v5 2
interface cem 0/0/16
cem 100
xconnect 10.2.2.2 10 encapsulation mpls
end
```

Note Overhead v5 has to be matched with the peer end.

Configuring AU-4 — TUG-3 — TUG-2 — VC-12

Use the following commands to configure AU-4 — TUG-3 — TUG-2 — VC-12:

```
enable
configure terminal
controller sdh 0/0/16
rate stm4
au-4 1
mode tug-3
tug-3 1
mode vc1x
tug-2 3 payload vc12
e1 1 cem-group 10 unframed
vc 1 overhead v5 2
end
```

Note Overhead v5 should match with the peer end.

Configuring AU-4 — TUG-3 — TUG-2 — VC-11 — VC

To configure AU-4 — TUG-3 — TUG-2 — VC-11 — VC:

```
enable
configure terminal
controller sdh 0/0/16
rate stm4
au-4 1
mode tug-3
tug-3 1
mode vc1x
tug-2 2 payload vc11
vc 1 cem-group 2 cep
end
```

Configuring AU-4 — TUG-3 — TUG-2 — VC-12 — VC

To configure AU-4 — TUG-3 — TUG-2 — VC-12 — VC:

```
enable
configure terminal
controller sdh 0/0/16
rate stm4
au-4 1
mode tug-3
tug-3 1
mode vc1x
tug-2 4 payload vc12
vc 1 cem-group 10 cep
end
```

Verifying Mode VC-1x Configuration

Use **show running-configuration** command to verify mode VC-1x configuration.

```
#show running-configuration
controller MediaType 0/3/4
mode sdh
controller SDH 0/3/4
rate STM4
no ais-shut
alarm-report all
threshold sf-ber 3
clock source internal
overhead s1s0 0
aug mapping au-4
au-4 1
clock source internal
mode tug-3
tug-3 1
mode VC1x
tug-2 1 payload VC11
t1 1 cem-group 1 unframed
tug-2 2 payload VC11
vc 1 cem-group 2 cep
tug-2 3 payload VC12
e1 1 cem-group 3 unframed
tug-2 4 payload VC12
vc 1 cem-group 4 cep
tug-2 5 payload VC11
tug-2 6 payload VC11
tug-2 7 payload VC11
!
tug-3 2
!
tug-3 3
!
au-4 2
!
au-4 3
!
au-4 4
```

Configuring Mode VC-4 Nc

To configure mode VC-4 Nc:

```
enable
configure terminal
controller sdh 0/0/16
au-4 1 - 4 mode vc4-4c
cem-group 100 cep
end
```



Note Overhead C2 should match with the peer end else it will result in PPLM alarm.

Verifying Mode VC-4 Nc Configuration

Use **show running-configuration** command to verify mode VC-4 Nc configuration.

```
#show running-configuration
platform enable
controller MediaType 0/0/16 oc12
controller MediaType 0/0/16
mode sdh
controller SDH 0/0/16
rate STM4
no ais-shut
alarm-report all
threshold sf-ber 3
clock source internal
overhead s1s0 0
aug mapping au-4
au-4 1 - 4 mode vc4-4c
clock source internal
cem-group 10 cep
interface CEM 0/0/16
no ip address
cem 10
```

Configuring AU-3 — VC-3 — DS3

To configure AU-3 — VC-3 — DS3:

```
enable
configure terminal
controller MediaType 0/0/16
mode sdh
controller sdh 0/0/16
rate stm4
au-3 1
mode t3
cem-group 100 unframed
end
```

Configuring AU-3 — VC-3 — E3

To configure AU-3 — VC-3 — E3:

```
enable
configure terminal
controller sdh 0/0/16
rate stm4
au-3 1
mode e3
cem-group 100 unframed
end
```

Configuring Modes under AU-3 Mapping

This section describes the configuration of modes under AU-3 mapping.

Configuring Mode VC-1x

To configure mode VC-1x:

```
enable
configure terminal
controller sdh 0/0/16
rate stm4
```

```
au-3 1
mode VC1x
tug-2 1 payload VC11
tug-2 2 payload VC11
tug-2 3 payload VC11
tug-2 4 payload VC11
tug-2 5 payload VC11
tug-2 6 payload VC11
tug-2 7 payload VC11
end
end
```

Configuring AU-3 — TUG-2 — VC-11 — VC

To configure AU-3 — TUG-2 — VC-11 — VC:

```
configure terminal
controller MediaType 0/0/16
mode sdh
controller sdh 0/0/16
rate stm4
au-3 1
mode vc1x
tug-2 1 payload vc11
vc 1 cem-group 10 cep
end
```

Configuring AU-3 — TUG-2 — VC-12 — VC

To configure AU-3 — TUG-2 — VC-12 — VC:

```
configure terminal
controller MediaType 0/0/16
mode sdh
controller sdh 0/0/16
rate stm4
au-3 1
mode vc1x
tug-2 1 payload vc12
vc 1 cem-group 10 cep
end
```

Configuring AU-3 — TUG-2 — VC-11 — T1

To configure AU-3 — TUG-2 — VC-11 — T1:

```
configure terminal
controller MediaType 0/0/16
mode sdh
controller sdh 0/0/16
rate stm4
au-3 1
mode vc1x
tug-2 1 payload vc11
t1 1 cem-group 10 unframed
vc 1 overhead v5 2
interface cem 0/0/16
cem 100
xconnect 10.2.2.2 10 encapsulation mpls
end
```

Configuring AU-3 — TUG-2 — VC-12 — E1

To configure AU-3 — TUG-2 — VC-12 — E1:

```
configure terminal
controller MediaType 0/0/16
mode sdh
controller sdh 0/0/16
rate stm4
au-3 1
mode vc1x
tug-2 3 payload vc12
e1 1 cem-group 10 unframed
vc 1 overhead v5 2
end
```

Verifying Mode VC-1x Configuration

Use **show running-configuration** command to verify mode VC-1x configuration.

```
#show running-configuration
controller MediaType 0/0/16
mode sdh
controller SDH 0/0/16
rate STM4
no ais-shut
alarm-report all
threshold sf-ber 3
clock source internal
overhead s1s0 0
aug mapping au-3
au-3 1
clock source internal
mode VC1x
tug-2 1 payload VC11
t1 1 cem-group 1 unframed
tug-2 2 payload VC11
vc 1 cem-group 2 cep
tug-2 3 payload VC12
tug-2 4 payload VC12
vc 1 cem-group 4 cep
tug-2 5 payload VC11
tug-2 6 payload VC11
tug-2 7 payload VC11
```

Configuring AU-4 — TUG-3 — TUG-2 — VC-12 for Framed SAToP

Use the following commands to configure AU-4 — TUG-3 — TUG-2 — VC-12 for framed SAToP under mode VC-1x (AU-4 mapping):

```
enable
configure terminal
controller sdh 0/0/16
rate stm4
au-4 1
mode tug-3
tug-3 1
mode vc1x
tug-2 3 payload vc12
e1 1 cem-group 1 framed
```

```
vc 1 overhead v5 2
end
```

Configuring AU-3 — TUG-2 — VC-11 — T1 for Framed SAToP

To configure AU-3 — TUG-2 — VC-11 — T1 for framed SAToP under mode VC-1x (AU-3 mapping):

```
configure terminal
controller MediaType 0/0/16
mode sdh
controller sdh 0/0/16
rate stm4
au-3 1
mode vc1x
tug-2 1 payload vc11
t1 1 cem-group 0 framed
vc 1 overhead v5 2
interface cem 0/0/16
cem 100
xconnect 10.2.2.2 10 encapsulation mpls
end
```

Verifying SDH Configuration for Framed SAToP

Use **show running configuration** command to verify SDH configuration for Framed SAToP:

```
Router#show running configuration | sec 0/0/16
platform enable controller mediatype 0/0/16 oc3
controller mediatype 0/0/16
mode sdh
controller sdh 0/0/16
rate stm1
no ais-shut
alarm-report all
clock source internal
overhead s1s0 0
aug mapping au-4
au-4 1
clock source internal
mode tug-3
tug-3 1
mode vc1x
tug-2 1 payload vc11
tug-2 2 payload vc12
e1 1 cem-group 1 framed
tug-2 3 payload vc11
tug-2 4 payload vc11
tug-2 5 payload vc11
tug-2 6 payload vc11
tug-2 7 payload vc11
!
interface cem 0/0/16
no ip address
cem 0
!
cem 1
!
cem 2
!
```

```
cem 3
!
Router#
```

Restrictions for SDH

- The maximum supported bandwidth is STM-16.
- Any Port (16-19) is configurable for STM-1, STM-4 or STM-16.
- The IM has 4 X STM-4 ports. You can configure STM-1 or STM-4 on all four ports. If you configure rate STM-16 on any of the four ports, others ports will not be available.
- This IM does not support CEP on AU-4 — VC-4 — TUG-3 — VC-3.
- This IM does not support CT3, CE3, CT3-E1 under the VC3 container. Only clear channel T3 services are supported.
- This IM does not support the framed SAToP CESoPSN.
- Eight BERT engines are supported for Higher Order and 16 BERT engines are supported for Lower Order hierarchy.
- If a port is configured as SDH, all ports can only be configured as SDH unless the mode SDH is removed from all the ports on the IM.
- VC-4-64c and VC-2 are not supported.
- AU-4 CT3, AU-4 CE3, AU-4 CT3-E1, AU-3-CT3, AU-3-CE3, and AU-3 CT3-E1 are not supported.

  AU-4 — VC-4 — TUG-3 — VC-3 — DS3 — T1/E1, AU-4 — VC-4 — TUG-3 — VC-3 — E3 — E1, AU-3 — VC-3 — DS3 — T1/E1, and AU-3 — VC-3 — E3 — E1 are not supported.
- Concatenation VC-4-Nc is only supported for augment mapping AU-4.
- MDL is not supported.
- SNCP is not supported.

Restrictions on Bandwidth

- Total available bandwidth is 2.5G.

  The following configuration is blocked and an error message is displayed after the maximum bandwidth is utilized:

  ```
  rate stm1 | rate stm4 | rate stm16
  ```

Table 14: Bandwidth Used by Different Rates

Rate	Bandwidth (kbit/s)
STM-1	150,336
STM-4	601,344
STM-16	2,405,376

Restrictions for Scale PW Circuits

- Only 1000 CEM PW Circuits per OCN Interface modules are supported.

Restrictions for BER Threshold

- The BER threshold value 10e-9 is not supported for the following line, path, and VT BER CLIs on the following interface modules:
  - Line BER CLIs **threshold b2-tca**, **threshold sd-ber** and **threshold sf-ber**.
  - PATH BER CLIs **threshold b3-ber_sd**, **threshold b3-ber_sf**, and **threshold b3-tca**.
  - VT BER CLIs **threshold bip2-sd**, **threshold bip2-sf**, and **threshold bip2-tca**.
  - **Not Supported Interface Modules for Above BER CLIs**
    - A900-IMA3G-IMSG
    - A900-IMA1Z8S-CXMS
    - A900-IMA1Z8S-CX

Configuring Mediatype Controller

Each SFP port (16-19) can be configured as STM-1, STM-4, STM-16.

You must select the MediaType controller to configure and enter the controller configuration mode.

You must configure the controller as a SDH port.

To configure MediaType Controller:

```
enable
configure terminal
controller MediaType 0/0/16
mode sdh
end
```

Configuring Rate on SDH Ports

To configure rate on SDH ports:

```
enable
configure terminal
controller MediaType 0/0/16
mode sdh
controller sdh 0/0/16
rate [stm1 | stm4 | stm16]
end
```

Note The configuration of **no** form of the command is not suported. To restore to the default condition, use **no mode sdh** command under Mediatype controller after removing all configuration under that port. .

SDH Line and Section Configuration Parameters

The following parameters affect SDH configuration at the line and section levels.

Overhead

Sets the SDH overhead bytes in the frame header to a specific standards requirement, or to ensure interoperability with equipment from another vendors.

- **J0** — Sets the J0 or C1 byte value in the SDH section overhead.

Note The supported values of J0 are 1 byte, 16 bytes, and 64 bytes.

- **S1S0** — Sets the SS bits value of the H1 byte in the SDH line overhead.

Configuring Line and Section Overhead

To configure line and section overhead:

```
enable
configure terminal
controller sdh 0/0/16
overhead s1s0 2
overhead j0 expected length 16-byte
overhead j0 expected tracebuffer rx Message
overhead j0 tx length 1-byte
overhead j0 tx tracebuffer tx Message
end
```

Note To restore the system to its default condition, use the **no** form of the **overhead j0** command.

Threshold

Set the path BER threshold values.

- **b1-tca** — Enables Bit Error Rate (BER) threshold crossing alerts for B1.
- **b2-tca** — Enables BER threshold crossing alerts for B2.
- **sd-ber** — Enables the threshold of the Signal Degrade (SD) BER that is used to trigger a signal degrade alarm.
- **sf-ber** — Configures the threshold of the Signal Failure (SF) BER that is used to trigger a link state change.

Configuring Line and Section Threshold

To configure line and section threshold:

```
enable
configure terminal
mode sdh
controller sdh 0/0/16
threshold b1-tca 5
threshold b2-tca 5
threshold sd-ber 5
threshold sf-ber 5
end
```



Note To restore the system to its default condition, use the **no** form of the threshold command.

Loopback

Sets a loopback to test the SDH port.

- local — Loops the signal from Tx to Rx path. Sends alarm indication signal (AIS) to network.
- network — Loops the signal from Rx to Tx path.

Configuring Line Loopback

To configure loopback:

```
enable
configure terminal
controller sdh 0/0/16
loopback [local | network]
end
```



Note To restore the system to its default condition, use the **no** form of the loopback command.



Note When loopback is configured as network, it is recommended to use the configuration of clock source as line.

AIS-Shut

Enables automatic insertion of a Line Alarm Indication Signal (LAIS) in the sent SDH signal whenever the SDH port enters the administrative shutdown state.

Configuring AIS Shut

To configure AIS-Shut:

```
enable
configure terminal
controller sdh 0/0/16
ais-shut
end
```

Note The **no ais-shut** command does not send AIS.

Shutdown

Disables the interface.

Configuring Shut

To configure Shut:

```
enable
configure terminal
controller sdh 0/0/16
shutdown
end
```

Note Use the **no shutdown** command to disable the interface.

Alarm Reporting

Enables reporting for all or selected alarms.

- **b1-tca** — Enables BER threshold crossing alarm for B1.
- **b2-tca** — Enables BER threshold crossing alarm for B2.
- **b3-tca** — Enables BER threshold crossing alarm for B3.
- **lais** —Enables line alarm indication signal.
- **lom** — Enables loss of multiframe signal.
- **lrdi** — Enables line remote defect indication signal.
- **pais** — Enables path alarm indication signal.
- **plop** — Enables loss of pointer failure signal for a path.
- **pplm** — Enables path payload mismatch indication.
- **prdi** — Enables path remote defect indication signal.
- **puneq** — Enables path unequipped (path label equivalent to zero) signal.
- **sd-ber** — Enables LBIP BER in excess of SD threshold.
- **sf-ber** — Enables LBIP BER in excess of SF threshold.
- **slof** — Enables section loss of frame signal.
- **slos** — Enables section loss of signal.

Configuring Alarm Reporting

To configure alarm reporting:

```
enable
configure terminal
controller sdh 0/0/16
alarm-report [b1-tca | b2-tca | b3-tca | lais | lom | lrdi | pais | plop | pplm | prdi |
puneq | sd-ber | sf-ber | lof | los]
end
```

Note To restore the system to its default condition, use the **no** form of the alarm report command.

Clock Source

Specifies the clock source, where

- **line** —The link uses the recovered clock from the line.
- **internal** — The link uses the internal clock source. This is the default setting.

Configuring Clock

To configure clock, use the following commands:

```
enable
configure terminal
controller sdh 0/0/16
clock source [line | internal]
end
```

Note The default mode is internal.

Note To restore the system to its default condition, use the **no** form of the command.

Configuring Network-Clock SDH

To configure network-clock SDH, use the following commands:

```
enable
configure terminal
controller sdh 0/0/16
clock source line
end
enable
configure terminal
network-clock input-source 1 controller sdh 0/0/16
end
```

Verifying SDH Line and Section Parameters Configuration

Use **show controllers** command to verify SDH Line and Section Parameters Configuration:

```
Rotuer#show controller sdh 0/7/7
SDH 0/7/7 is up.
Hardware is A900-IMA3G-IMSG
Port configured rate: STM16
 Applique type is Channelized SDH
 Clock Source is Internal, AUG mapping is AU4.
Medium info:
  Type: SDH, Line Coding: NRZ,
 Alarm Throttling: OFF
 Regenerator Section:
  LOS = 0          LOF = 0                           BIP(B1) = 0

SDH Section Tables
  INTERVAL       CV    ES   SES  SEFS
  21:24-21:24     0     0     0     0

Multiplex Section:
  AIS = 0          RDI = 0          REI = 0          BIP(B2) = 0
Active Defects: None
Detected Alarms: None
Asserted/Active Alarms: None
Alarm reporting enabled for: SLOS SLOF LAIS SF SD LRDI B1-TCA B2-TCA
BER thresholds:  SF = 10e-3  SD = 10e-6
TCA thresholds:  B1 = 10e-6  B2 = 10e-6
Rx: S1S0 = 00
    K1 = 00,   K2 = 00
    J0 = 00

    RX S1 = 00

Tx: S1S0 = 00
    K1 = 00,   K2 = 00
    J0 = 04

Tx J0 Length : 16
Tx J0 Trace :

  50 45 31 20 20 20 20 20 20 20 20 20 20 20 20 00     PE1            .

Expected J0 Length : 16
Expected J0 Trace :

  50 45 31 20 20 20 20 20 20 20 20 20 20 20 20 00     PE1            .

Rx J0 Length : 0
Rx J0 Trace :


SDH Line Tables
  INTERVAL       CV    ES   SES   UAS  CVFE  ESFE  SESFE  UASFE
  21:24-21:24     0     0     0     0     0     0      0      0


High Order Path:

PATH 1:
Clock Source is internal

  AIS = 0          RDI = 0          REI = 0          BIP(B3) = 0
  LOP = 0          PSE = 0          NSE = 0          NEWPTR = 0
```

```
  LOM = 0          PLM = 0          UNEQ = 0

Active Defects: None
Detected Alarms: PPLM
Asserted/Active Alarms: PPLM
Alarm reporting enabled for: PAIS PRDI PUNEQ PLOP PPLM LOM B3-TCA

TCA threshold:  B3 = 10e-6
Rx: C2 = FE
Tx: C2 = 01

Tx J1 Length : 16
Tx J1 Trace

  50 45 31 20 30 2F 37 2F 37 2E 31 00 00 00 00 00     PE1 0/7/7.1.....

Expected J1 Length : 16
Expected J1 Trace

  50 45 31 20 30 2F 37 2F 37 2E 31 00 00 00 00 00     PE1 0/7/7.1.....

PATH TRACE BUFFER : UNSTABLE

Rx J1 Length : 16
Rx J1 Trace
  CRC-7: 0xBA OK

  4F 4E 54 20 48 4F 2D 54 52 41 43 45 20 20 20 00     ONT HO-TRACE   .

SDH Path Tables
  INTERVAL       CV    ES   SES   UAS  CVFE  ESFE  SESFE  UASFE
  21:24-21:24     0     0     0     0     0     0      0      0

PATH 4:
Clock Source is internal

  AIS = 0          RDI = 0          REI = 0          BIP(B3) = 0
  LOP = 0          PSE = 0          NSE = 0          NEWPTR = 0
  LOM = 0          PLM = 0          UNEQ = 0

Active Defects: None
Detected Alarms: PPLM LOM
Asserted/Active Alarms: PPLM LOM
Alarm reporting enabled for: PAIS PRDI PUNEQ PLOP PPLM LOM B3-TCA

TCA threshold:  B3 = 10e-6
Rx: C2 = FE
Tx: C2 = 02

Tx J1 Length : 16
Tx J1 Trace

  50 45 31 20 30 2F 37 2F 37 2E 32 00 00 00 00 00     PE1 0/7/7.2.....

Expected J1 Length : 16
Expected J1 Trace

  50 45 31 20 30 2F 37 2F 37 2E 32 00 00 00 00 00     PE1 0/7/7.2.....

PATH TRACE BUFFER : UNSTABLE

Rx J1 Length : 16
Rx J1 Trace
  CRC-7: 0xBA OK
```

```
  4F 4E 54 20 48 4F 2D 54 52 41 43 45 20 20 20 00     ONT HO-TRACE   .

SDH Path Tables
  INTERVAL       CV    ES   SES   UAS  CVFE  ESFE  SESFE  UASFE
  21:23-21:24     0     0     0   382     0     0      0      0

PATH 7:
Clock Source is internal

  AIS = 0          RDI = 0          REI = 0          BIP(B3) = 0
  LOP = 0          PSE = 0          NSE = 0          NEWPTR = 0
  LOM = 0          PLM = 0          UNEQ = 0

Active Defects: None
Detected Alarms: None
Asserted/Active Alarms: None
Alarm reporting enabled for: PAIS PRDI PUNEQ PLOP PPLM LOM B3-TCA

TCA threshold:  B3 = 10e-6
Rx: C2 = 00
Tx: C2 = 00

Tx J1 Length : 16
Tx J1 Trace

  50 45 31 20 30 2F 37 2F 37 2E 33 00 00 00 00 00     PE1 0/7/7.3.....

Expected J1 Length : 16
Expected J1 Trace

  50 45 31 20 30 2F 37 2F 37 2E 33 00 00 00 00 00     PE1 0/7/7.3.....

PATH TRACE BUFFER : UNSTABLE

Rx J1 Length : 0
Rx J1 Trace


SDH Path Tables
  INTERVAL       CV    ES   SES   UAS  CVFE  ESFE  SESFE  UASFE
  21:24-21:25     0     0     0     0     0     0      0      0

PATH 10:
Clock Source is internal

  AIS = 0          RDI = 0          REI = 0          BIP(B3) = 0
  LOP = 0          PSE = 0          NSE = 0          NEWPTR = 0
  LOM = 0          PLM = 0          UNEQ = 0

Active Defects: None
Detected Alarms: None
Asserted/Active Alarms: None
Alarm reporting enabled for: PAIS PRDI PUNEQ PLOP PPLM LOM B3-TCA

TCA threshold:  B3 = 10e-6
Rx: C2 = 00
Tx: C2 = 00

Tx J1 Length : 16
Tx J1 Trace

  50 45 31 20 30 2F 37 2F 37 2E 34 00 00 00 00 00     PE1 0/7/7.4.....
```

```
Expected J1 Length : 16
Expected J1 Trace

  50 45 31 20 30 2F 37 2F 37 2E 34 00 00 00 00 00     PE1 0/7/7.4.....

PATH TRACE BUFFER : UNSTABLE

Rx J1 Length : 0
Rx J1 Trace


SDH Path Tables
  INTERVAL       CV    ES   SES   UAS  CVFE  ESFE  SESFE  UASFE
  21:25-21:25     0     0     0     0     0     0      0      0

PATH 13:
Clock Source is internal

  AIS = 0          RDI = 0          REI = 0          BIP(B3) = 0
  LOP = 0          PSE = 0          NSE = 0          NEWPTR = 0
  LOM = 0          PLM = 0          UNEQ = 0

Active Defects: None
Detected Alarms: None
Asserted/Active Alarms: None
Alarm reporting enabled for: PAIS PRDI PUNEQ PLOP PPLM LOM B3-TCA

TCA threshold:  B3 = 10e-6
Rx: C2 = 00
Tx: C2 = 00

Tx J1 Length : 16
Tx J1 Trace

  50 45 31 20 30 2F 37 2F 37 2E 35 00 00 00 00 00     PE1 0/7/7.5.....

Expected J1 Length : 16
Expected J1 Trace

  50 45 31 20 30 2F 37 2F 37 2E 35 00 00 00 00 00     PE1 0/7/7.5.....

PATH TRACE BUFFER : UNSTABLE

Rx J1 Length : 0
Rx J1 Trace


SDH Path Tables
  INTERVAL       CV    ES   SES   UAS  CVFE  ESFE  SESFE  UASFE
  21:25-21:25     0     0     0     0     0     0      0      0

PATH 16:
Clock Source is internal

  AIS = 0          RDI = 0          REI = 0          BIP(B3) = 0
  LOP = 0          PSE = 0          NSE = 0          NEWPTR = 0
  LOM = 0          PLM = 0          UNEQ = 0

Active Defects: None
Detected Alarms: None
Asserted/Active Alarms: None
Alarm reporting enabled for: PAIS PRDI PUNEQ PLOP PPLM LOM B3-TCA

TCA threshold:  B3 = 10e-6
```

```
Rx: C2 = 00
Tx: C2 = 00

Tx J1 Length : 16
Tx J1 Trace

  50 45 31 20 30 2F 37 2F 37 2E 36 00 00 00 00 00     PE1 0/7/7.6.....

Expected J1 Length : 16
Expected J1 Trace

  50 45 31 20 30 2F 37 2F 37 2E 36 00 00 00 00 00     PE1 0/7/7.6.....

PATH TRACE BUFFER : UNSTABLE

Rx J1 Length : 0
Rx J1 Trace


SDH Path Tables
  INTERVAL       CV    ES   SES   UAS  CVFE  ESFE  SESFE  UASFE
  21:25-21:25     0     0     0     0     0     0      0      0

PATH 19:
Clock Source is internal

  AIS = 0          RDI = 0          REI = 0          BIP(B3) = 0
  LOP = 0          PSE = 0          NSE = 0          NEWPTR = 0
  LOM = 0          PLM = 0          UNEQ = 0

Active Defects: None
Detected Alarms: None
Asserted/Active Alarms: None
Alarm reporting enabled for: PAIS PRDI PUNEQ PLOP PPLM LOM B3-TCA

TCA threshold:  B3 = 10e-6
Rx: C2 = 00
Tx: C2 = 00

Tx J1 Length : 16
Tx J1 Trace

  50 45 31 20 30 2F 37 2F 37 2E 37 00 00 00 00 00     PE1 0/7/7.7.....

Expected J1 Length : 16
Expected J1 Trace

  50 45 31 20 30 2F 37 2F 37 2E 37 00 00 00 00 00     PE1 0/7/7.7.....

PATH TRACE BUFFER : UNSTABLE

Rx J1 Length : 0
Rx J1 Trace


SDH Path Tables
  INTERVAL       CV    ES   SES   UAS  CVFE  ESFE  SESFE  UASFE
  21:25-21:25     0     0     0     0     0     0      0      0

PATH 22:
Clock Source is internal

  AIS = 0          RDI = 0          REI = 0          BIP(B3) = 0
  LOP = 0          PSE = 0          NSE = 0          NEWPTR = 0
```

```
  LOM = 0          PLM = 0          UNEQ = 0

Active Defects: None
Detected Alarms: None
Asserted/Active Alarms: None
Alarm reporting enabled for: PAIS PRDI PUNEQ PLOP PPLM LOM B3-TCA

TCA threshold:  B3 = 10e-6
Rx: C2 = 00
Tx: C2 = 00

Tx J1 Length : 16
Tx J1 Trace

  50 45 31 20 30 2F 37 2F 37 2E 38 00 00 00 00 00     PE1 0/7/7.8.....

Expected J1 Length : 16
Expected J1 Trace

  50 45 31 20 30 2F 37 2F 37 2E 38 00 00 00 00 00     PE1 0/7/7.8.....

PATH TRACE BUFFER : UNSTABLE

Rx J1 Length : 0
Rx J1 Trace


SDH Path Tables
  INTERVAL       CV    ES   SES   UAS  CVFE  ESFE  SESFE  UASFE
  21:25-21:25     0     0     0     0     0     0      0      0

PATH 25:
Clock Source is internal

  AIS = 0          RDI = 0          REI = 0          BIP(B3) = 0
  LOP = 0          PSE = 0          NSE = 0          NEWPTR = 0
  LOM = 0          PLM = 0          UNEQ = 0

Active Defects: None
Detected Alarms: None
Asserted/Active Alarms: None
Alarm reporting enabled for: PAIS PRDI PUNEQ PLOP PPLM LOM B3-TCA

TCA threshold:  B3 = 10e-6
Rx: C2 = 00
Tx: C2 = 00

Tx J1 Length : 16
Tx J1 Trace

  50 45 31 20 30 2F 37 2F 37 2E 39 00 00 00 00 00     PE1 0/7/7.9.....

Expected J1 Length : 16
Expected J1 Trace

  50 45 31 20 30 2F 37 2F 37 2E 39 00 00 00 00 00     PE1 0/7/7.9.....

PATH TRACE BUFFER : UNSTABLE

Rx J1 Length : 0
Rx J1 Trace


SDH Path Tables
```

```
  INTERVAL       CV    ES   SES   UAS  CVFE  ESFE  SESFE  UASFE
  21:25-21:25     0     0     0     0     0     0      0      0

PATH 28:
Clock Source is internal

  AIS = 0          RDI = 0          REI = 0          BIP(B3) = 0
  LOP = 0          PSE = 0          NSE = 0          NEWPTR = 0
  LOM = 0          PLM = 0          UNEQ = 0

Active Defects: None
Detected Alarms: None
Asserted/Active Alarms: None
Alarm reporting enabled for: PAIS PRDI PUNEQ PLOP PPLM LOM B3-TCA

TCA threshold:  B3 = 10e-6
Rx: C2 = 00
Tx: C2 = 00

Tx J1 Length : 16
Tx J1 Trace

  50 45 31 20 30 2F 37 2F 37 2E 31 30 00 00 00 00     PE1 0/7/7.10....

Expected J1 Length : 16
Expected J1 Trace

  50 45 31 20 30 2F 37 2F 37 2E 31 30 00 00 00 00     PE1 0/7/7.10....

PATH TRACE BUFFER : UNSTABLE

Rx J1 Length : 0
Rx J1 Trace


SDH Path Tables
  INTERVAL       CV    ES   SES   UAS  CVFE  ESFE  SESFE  UASFE
  21:25-21:25     0     0     0     0     0     0      0      0

PATH 31:
Clock Source is internal

  AIS = 0          RDI = 0          REI = 0          BIP(B3) = 0
  LOP = 0          PSE = 0          NSE = 0          NEWPTR = 0
  LOM = 0          PLM = 0          UNEQ = 0

Active Defects: None
Detected Alarms: None
Asserted/Active Alarms: None
Alarm reporting enabled for: PAIS PRDI PUNEQ PLOP PPLM LOM B3-TCA

TCA threshold:  B3 = 10e-6
Rx: C2 = 00
Tx: C2 = 00

Tx J1 Length : 16
Tx J1 Trace

  50 45 31 20 30 2F 37 2F 37 2E 31 31 00 00 00 00     PE1 0/7/7.11....

Expected J1 Length : 16
Expected J1 Trace

  50 45 31 20 30 2F 37 2F 37 2E 31 31 00 00 00 00     PE1 0/7/7.11....
```

```
PATH TRACE BUFFER : UNSTABLE

Rx J1 Length : 0
Rx J1 Trace


SDH Path Tables
  INTERVAL       CV    ES   SES   UAS  CVFE  ESFE  SESFE  UASFE
  21:25-21:25     0     0     0     0     0     0      0      0

PATH 34:
Clock Source is internal

  AIS = 0          RDI = 0          REI = 0          BIP(B3) = 0
  LOP = 0          PSE = 0          NSE = 0          NEWPTR = 0
  LOM = 0          PLM = 0          UNEQ = 0

Active Defects: None
Detected Alarms: None
Asserted/Active Alarms: None
Alarm reporting enabled for: PAIS PRDI PUNEQ PLOP PPLM LOM B3-TCA

TCA threshold:  B3 = 10e-6
Rx: C2 = 00
Tx: C2 = 00

Tx J1 Length : 16
Tx J1 Trace

  50 45 31 20 30 2F 37 2F 37 2E 31 32 00 00 00 00     PE1 0/7/7.12....

Expected J1 Length : 16
Expected J1 Trace

  50 45 31 20 30 2F 37 2F 37 2E 31 32 00 00 00 00     PE1 0/7/7.12....

PATH TRACE BUFFER : UNSTABLE

Rx J1 Length : 0
Rx J1 Trace


SDH Path Tables
  INTERVAL       CV    ES   SES   UAS  CVFE  ESFE  SESFE  UASFE
  21:25-21:25     0     0     0     0     0     0      0      0

PATH 37:
Clock Source is internal

  AIS = 0          RDI = 0          REI = 0          BIP(B3) = 0
  LOP = 0          PSE = 0          NSE = 0          NEWPTR = 0
  LOM = 0          PLM = 0          UNEQ = 0

Active Defects: None
Detected Alarms: None
Asserted/Active Alarms: None
Alarm reporting enabled for: PAIS PRDI PUNEQ PLOP PPLM LOM B3-TCA

TCA threshold:  B3 = 10e-6
Rx: C2 = 00
Tx: C2 = 00

Tx J1 Length : 16
```

```
Tx J1 Trace

  50 45 31 20 30 2F 37 2F 37 2E 31 33 00 00 00 00     PE1 0/7/7.13....

Expected J1 Length : 16
Expected J1 Trace

  50 45 31 20 30 2F 37 2F 37 2E 31 33 00 00 00 00     PE1 0/7/7.13....

PATH TRACE BUFFER : UNSTABLE

Rx J1 Length : 0
Rx J1 Trace


SDH Path Tables
  INTERVAL       CV    ES   SES   UAS  CVFE  ESFE  SESFE  UASFE
  21:25-21:25     0     0     0     0     0     0      0      0

PATH 40:
Clock Source is internal

  AIS = 0          RDI = 0          REI = 0          BIP(B3) = 0
  LOP = 0          PSE = 0          NSE = 0          NEWPTR = 0
  LOM = 0          PLM = 0          UNEQ = 0

Active Defects: None
Detected Alarms: None
Asserted/Active Alarms: None
Alarm reporting enabled for: PAIS PRDI PUNEQ PLOP PPLM LOM B3-TCA

TCA threshold:  B3 = 10e-6
Rx: C2 = 00
Tx: C2 = 00

Tx J1 Length : 16
Tx J1 Trace

  50 45 31 20 30 2F 37 2F 37 2E 31 34 00 00 00 00     PE1 0/7/7.14....

Expected J1 Length : 16
Expected J1 Trace

  50 45 31 20 30 2F 37 2F 37 2E 31 34 00 00 00 00     PE1 0/7/7.14....

PATH TRACE BUFFER : UNSTABLE

Rx J1 Length : 0
Rx J1 Trace


SDH Path Tables
  INTERVAL       CV    ES   SES   UAS  CVFE  ESFE  SESFE  UASFE
  21:26-21:26     0     0     0     0     0     0      0      0

PATH 43:
Clock Source is internal

  AIS = 0          RDI = 0          REI = 0          BIP(B3) = 0
  LOP = 0          PSE = 0          NSE = 0          NEWPTR = 0
  LOM = 0          PLM = 0          UNEQ = 0

Active Defects: None
Detected Alarms: None
```

```
Asserted/Active Alarms: None
Alarm reporting enabled for: PAIS PRDI PUNEQ PLOP PPLM LOM B3-TCA

TCA threshold:  B3 = 10e-6
Rx: C2 = 00
Tx: C2 = 00

Tx J1 Length : 16
Tx J1 Trace

  50 45 31 20 30 2F 37 2F 37 2E 31 35 00 00 00 00     PE1 0/7/7.15....

Expected J1 Length : 16
Expected J1 Trace

  50 45 31 20 30 2F 37 2F 37 2E 31 35 00 00 00 00     PE1 0/7/7.15....

PATH TRACE BUFFER : UNSTABLE

Rx J1 Length : 0
Rx J1 Trace


SDH Path Tables
  INTERVAL       CV    ES   SES   UAS  CVFE  ESFE  SESFE  UASFE
  21:26-21:26     0     0     0     0     0     0      0      0

PATH 46:
Clock Source is internal

  AIS = 0          RDI = 0          REI = 0          BIP(B3) = 0
  LOP = 0          PSE = 0          NSE = 0          NEWPTR = 0
  LOM = 0          PLM = 0          UNEQ = 0

Active Defects: None
Detected Alarms: None
Asserted/Active Alarms: None
Alarm reporting enabled for: PAIS PRDI PUNEQ PLOP PPLM LOM B3-TCA

TCA threshold:  B3 = 10e-6
Rx: C2 = 00
Tx: C2 = 00

Tx J1 Length : 16
Tx J1 Trace

  50 45 31 20 30 2F 37 2F 37 2E 31 36 00 00 00 00     PE1 0/7/7.16....

Expected J1 Length : 16
Expected J1 Trace

  50 45 31 20 30 2F 37 2F 37 2E 31 36 00 00 00 00     PE1 0/7/7.16....

PATH TRACE BUFFER : UNSTABLE

Rx J1 Length : 0
Rx J1 Trace


SDH Path Tables
  INTERVAL       CV    ES   SES   UAS  CVFE  ESFE  SESFE  UASFE
  21:26-21:26     0     0     0     0     0     0      0      0
```

```
SDH 0/7/7.1 PATH  mode vc4 is down
  cep is configured: TRUE cem_id  :20
  clock source internal

 AU-4 2, TUG-3 1, TUG-2 1, VC12 1 (SDH 0/7/7.2/1/1/1 VC12) is down
 VT Receiver has LP-RDI.
  cep is configured: FALSE cem_id  (0)
  fwd_alarm_ais :0    fwd_alarm_rai :0
  Framing is unframed, Clock Source is Internal
  BIP2-tca:6, BIP2-sf:3, BIP2-sd:6
  Tx V5:1
  Rx V5:6
  Tx J2 Length=16
  TX J2 Trace Buffer:
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

  Expected J2 Length=16
  Expected J2 Trace Buffer:
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

  Rx J2 Length=16
  RX J2 Trace Buffer:
  CRC-7: 0x81 OK

  4F 4E 54 20 4C 4F 2D 54 52 41 43 45 20 20 20 00     ONT LO-TRACE   .

 Data in curerent interval (140 seconds elapsed)
   Near End
    0 CodeViolations, 0 ErrorSecs, 0 Severly Err Secs, 269 Unavailable Secs
   Far End
    0 CodeViolations, 0 ErrorSecs, 0 Severly Err Secs, 0 Unavailable Secs

 AU-4 2, TUG-3 1, TUG-2 1, E1 1 (SDH 0/7/7.2/1/1/1 E1) is down
  Receiver is getting AIS.
  Framing is unframed, Clock Source is Internal
  Data in current interval (140 seconds elapsed):
   Near End
     0 Line Code Violations, 0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
     293 Unavail Secs, 0 Stuffed Secs
   Far End
     0 Line Code Violations, 0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
     0 Unavail Secs

 AU-4 2, TUG-3 1, TUG-2 1, VC12 2 (SDH 0/7/7.2/1/1/2 VC12) is down
 VT Receiver has LP-RDI.
  cep is configured: FALSE cem_id  (0)
  fwd_alarm_ais :0    fwd_alarm_rai :0
  Framing is unframed, Clock Source is Internal
  BIP2-tca:6, BIP2-sf:3, BIP2-sd:6
  Tx V5:1
  Rx V5:6
  Tx J2 Length=16
  TX J2 Trace Buffer:
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

  Expected J2 Length=16
  Expected J2 Trace Buffer:
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

  Rx J2 Length=16
```

```
 RX J2 Trace Buffer:
 CRC-7: 0x81 OK

 4F 4E 54 20 4C 4F 2D 54 52 41 43 45 20 20 20 00     ONT LO-TRACE   .

Data in curerent interval (150 seconds elapsed)
  Near End
   0 CodeViolations, 0 ErrorSecs, 0 Severly Err Secs, 483 Unavailable Secs
  Far End
   0 CodeViolations, 0 ErrorSecs, 0 Severly Err Secs, 0 Unavailable Secs

AU-4 2, TUG-3 1, TUG-2 1, E1 2 (SDH 0/7/7.2/1/1/2 E1) is down
 Receiver is getting AIS.
 Framing is unframed, Clock Source is Internal
 Data in current interval (150 seconds elapsed):
  Near End
    0 Line Code Violations, 0 Path Code Violations
    0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
    0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
    90 Unavail Secs, 0 Stuffed Secs
  Far End
    0 Line Code Violations, 0 Path Code Violations
    0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
    0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
    0 Unavail Secs
```

Configuring SDH Path Parameters

This section describes the configuration of SDH path parameters.

Path Overhead

J1 Flag

Sets the message length and the message text of the High Order Path Trace identifier (J1).

C2 Flag

Sets the C2 byte in the Path OverHead (POH) to indicate the contents of the payload inside the frame.

The path overheads, C2 flag and J1 flag can be configured for the following modes:

- AU-4 Mapping
  - Mode VC-4
  - Mode VC-4 Nc
  - Mode TUG-3

    For more information, refer Configuring Modes under AU-4 Mapping, on page 88.
- AU-3 Mapping
  - Mode E3
  - Mode T3

    For more information, refer Configuring Modes under AU-3 Mapping.

Configuring C2 Flag

To configure the C2 flag:

```
enable
configure terminal
controller Mediatype 0/0/16
mode sdh
controller sdh 0/0/16
au-4 1
overhead c2 10
end
```

J1 Flag

To configure the J1 flag:

```
enable
configure terminal
controller MediaType 0/0/16
mode sdh
controller sdh 0/0/16
au-4 1
overhead j1 expected length 16
overhead j1 expected message expectedmessage
overhead j1 tx length 16
overhead j1 tx message testmessage
end
```

Path Threshold

Set the path BER threshold values.

- **b3-tca** — Enables BER threshold crossing alerts for B3.
- **sd-ber** — Enables the threshold of the Signal Degrade (SD) BER that is used to trigger a signal degrade alarm.
- **sf-ber** — Configures the threshold of the Signal Failure (SF) BER that is used to trigger a link state change.

The path threshold can be configured for the following modes:

- AU-4 Mapping
  - Mode VC-4
  - Mode VC-4 Nc
  - Mode TUG-3

    For more information, refer Configuring Modes under AU-4 Mapping, on page 88.
- AU-3 Mapping
  - For more information, refer Configuring Modes under AU-3 Mapping.

Configuring Path Threshold

To configure path threshold:

```
enable
configure terminal
controller MediaType 0/0/16
mode sdh
controller sdh 0/0/16
au-4 1
threshold b3-ber_sd 7
threshold b3-ber_sf 7
end
```

Path Loopback

Sets a loopback to test the SDH port.

- local — Loops the signal from Tx to Rx path. Sends alarm indication signal (AIS) to network.
- network — Loops the signal from Rx to Tx path.

Configuring Path Loopback

To configure path loopback:

```
enable
configure terminal
controller sdh 0/0/16
au-4 1
loopback [local | network]
end
```

Note To restore the system to its default condition, use the **no** form of the command.

Configuring Path BERT

For more information on BERT configuration, see Configuring BERT in SDH for SAToP, on page 118 section.

Verifying Path Parameters Configuration

Use **show running-configuration** command to verify path parameters configuration.

```
#show running-configuration
controller MediaType 0/0/16
mode sdh
controller SDH 0/0/16
rate STM16
no ais-shut
alarm-report all
clock source internal
overhead s1s0 0
aug mapping au-4
au-4 1
mode vc4
clock source internal
loopback local
overhead c2 10
threshold b3-ber_sd 7
threshold b3-ber_sf 7
overhead j1 tx message STRING
overhead j1 expected message STRING
```

```
threshold b3-tca 5
au-4 2
```

Configuring BERT in SDH for SAToP

Bit-Error Rate Testing (BERT) is used to analyze quality and to resolve problems of digital transmission equipment. BERT tests the quality of an interface by directly comparing a pseudorandom or repetitive test pattern with an identical locally generated test pattern.

The BERT operation is data-intensive. Regular data cannot flow on the path while the test is in progress. The path is reported to be in alarm state when BERT is in progress and restored to a normal state after BERT has terminated.

BERT is supported in the following two directions:

- Line - Supports BERT in TDM direction.
- System - Supports BERT in PSN direction. CEM must be configured before running BERT towards system direction.

For BERT patterns supported on SDH, see BERT Patterns on 1-Port OC-48 or 4-Port OC-12/OC-3 CEM Interface Module.

BERT Patterns on 1-Port OC-48 or 4-Port OC-12/OC-3 CEM Interface Module

Table 15: Feature History

Feature Name	Release Information	Description
Support for all 0s and 1s BERT Patterns	Cisco IOS XE Bengaluru 17.4.1	Support for all 0s and 1s BERT patterns for SONET and SDH.

The BERT patterns on the 1-Port OC-48 or 4-Port OC-12/OC-3 interface module are:

Table 16: BERT Pattern Descriptions

Keyword	Description
All 1s 2	Pseudo-random binary test pattern consisting of all 1’s that is used to test alternating line volt and repeaters.
All 0s	Pseudo-random binary test pattern consisting of all 0’s that is used for test line coding.
2^15-1 O.151	Pseudo-random O.151 test pattern consisting of a maximum of 14 consecutive zeros and 15 consecutive ones. The length of this pattern is 32,768 bits.
2^20-O.151	Pseudo-random O.151 test pattern consisting of a maximum of 19 consecutive zeros and 20 consecutive ones. The length of this pattern is 1,048,575 bits.

Keyword	Description
2^20-O.153	Pseudo-random O.153 test pattern consisting of a maximum of 19 consecutive zeros and 20 consecutive ones. The length of this pattern is 1,048,575 bits.
2^23-1 O.151	Pseudo-random 0.151 test pattern consisting of a maximum of 22 consecutive zeros and 23 consecutive ones. The length of this pattern is 8,388,607 bits.
2^9 [3]	Pseudo-random binary test pattern consisting of a maximum of eight consecutive zeros and nine consecutive ones. The length of this pattern is 511 bits.
2^11 [4]	Pseudo-random binary test pattern consisting of a maximum of ten consecutive zeros and eleven consecutive ones. The length of this pattern is 2048 bits.

[2] All 1s are supported only on SONET CT3, SDH AU-3 - CT3/CE3 - T1/E1, and SDH AU-3 - VC3. Starting with Cisco IOS XE Bengaluru 17.4.1, All Is are supported on all modes.

[3] Starting with Cisco IOS XE Bengaluru 17.4.1, 2^9 mode is supported.

2^9 is not supported on the following modes:

- SONET—Unframed, STS-3c, STS-12c, and STS-48c.
- SDH AU-4—VC4, TUG-3-VC3, TUG-3-E3, TUG-3-T3, and TUG-3 - VC1x.
- SDH AU-3—VC3, VC4-4c, VC4-16c, and VC1x.

[4] Starting with Cisco IOS XE Bengaluru 17.4.1, 2^11 mode is supported.

2^11 is not supported on the following modes:

- SONET—Unframed, STS-3c, STS-12c, and STS-48c.
- SDH AU-4—VC4 and TUG-3-VC3.
- SDH AU-3—VC3, VC4-4c, and VC4-16c.



Note If All 1's BERT pattern is tested on the system side, then ensure that you need to start all 1's pattern from both sides of the end points.

Configuring BERT on one side and loopback on other side of the end points is not supported. The router treats all 1's pattern as AIS alarm and BERT will not come in sync with the other side configuration of the end point.

Configuring BERT in Modes VC-4 and VC Nc

To configure BERT in modes VC-4 and VC Nc:

```
configure terminal
controller sdh 0/0/16
rate STM1
no ais-shut
alarm-report all
clock source internal
overhead s1s0 0
aug mapping au-4
au-4 1
mode vc4
clock source internal
bert pattern 2^15 internal 10 direction [line | system]
```

Verifying BERT Configuration in Modes VC-4 and VC Nc

Use **show controllers** command to verify BERT Configuration in Modes VC-4 and VC Nc:

```
#show controller sdh 0/0/16 | sec BERT
BERT test result (running)Test Pattern : 2^15,
Status : Sync, Sync Detected : 0Interval : 10 minute(s),
Time Remain : 00:09:47
Bit Errors (since BERT started): 0 Mbits,Bits Received (since BERT started): 0 Mbits
Bit Errors (since last sync): 1943 bits
Bits Received (since last sync): 1943 Kbits
Direction : LineRouter#
```

Configuring E1 Bert

To configure E1 Bert:

```
enable
configure terminal
controller MediaType 0/0/16
mode sdh
controller sdh 0/0/16
rate stm4
au-3 1
mode vc1x
tug-2 1 payload vc12
e1 1 bert pattern 2^11 interval 10
end
```

Configuring T1 Bert

To configure T1 Bert:

```
enable
configure terminal
controller sdh 0/0/16
rate stm4
au-3 1
mode vc1x
tug-2 1 payload vc11
t1 1 bert pattern 2^11 interval 10
end
```

Configuring BERT in Mode T3/E3

To configure BERT in Mode T3/E3 for both AUG mapping AU-3 and AU-4:

```
configure terminal
controller sdh 0/0/16
rate STM1
no ais-shut
alarm-report all
clock source internal
overhead s1s0 0
aug mapping au-4
au-4 1
mode tug-3
clock source internal
tug-3 1
mode t3
threshold b3-tca 0
overhead c2 0
t3 clock source internal
t3 bert pattern 2^15 internal 10 direction [line | system]
```

Verifying BERT Configuration in Mode T3 or E3

Use **show controllers** command to verify BERT configuration in mode T3 or E3:

```
show controller sdh 0/0/16 | sec BERT
BERT test result (running)Test Pattern : 2^15,
Status : Sync, Sync Detected : 0Interval : 10 minute(s),
Time Remain : 00:09:47
Bit Errors (since BERT started): 0 Mbits,
Bits Received (since BERT started): 0 Mbits
Bit Errors (since last sync): 1943 bits
Bits Received (since last sync): 1943 Kbits
Direction : Line
```

Configuring BERT in Mode VC-1x

To configure BERT in mode VC-1x for both AUG mapping AU-3 and AU-4:

```
configure terminal
controller sdh 0/0/16
rate STM1
no ais-shut
alarm-report all
clock source internal
overhead s1s0 0
aug mapping au-4
au-4 1
mode tug-3
clock source internal
tug-3 1
mode vc-1x
tug-2 1 payload VC11
vc 1 bert pattern 2^15 internal 10 direction [line | system]
```

Verifying BERT Configuration in Mode VC-1x

Use **show controllers** command to verify BERT configuration in mode VC-1x:

```
#show controller sdh 0/0/16 | sec BERT
BERT test result (running)Test Pattern : 2^15,
Status : Sync, Sync Detected : 0Interval : 10 minute(s),
Time Remain : 00:09:47Bit Errors (since BERT started): 0 Mbits,Bits Received (since BERT
started): 0 Mbits
Bit Errors (since last sync): 1943 bits
Bits Received (since last sync): 1943 Kbits
Direction : Line
```

SDH T1/E1 Configuration Parameters

The following parameters affect SDH T1/E1 configuration:

- **BERT** — Starts the BERT test.
- **CEM Group** — Creates a circuit emulation (CEM) channel from one or more time slots of a T1 or E1 line of an NM-CEM-4TE1 network module,
- **Clock** — Specifies the clock source for T1 or E1 interface.
- **Description** — Specifies the description of the controller.
- **Loopback** — Sets the T1 or E1 interface in the loopback mode.

Configuring T1/E1 Parameters

To configure T1/E1 parameters:

```
enable
configure terminal
controller sdh 0/0/16
rate stm4
au-3 1
mode vc1x
tug-2 1 payload vc11
t1 1 loopback [local | network line]
t1 1 clock source [line | internal | recovered]
end
```

Note Loopback network payload is not supported. This is applicable for AU-4 Vc-1x and AU-3 Vc-1x modes.

Note If T1/E1 is enabled on a particular J/K/L/M, you can only configure overhead and threshold for that J/K/L/M value.

Guidelines for appending channel-group number to E1 serial interface on SDH

In E1 mode on SDH, starting from Cisco IOS XE release 17.2.1, the naming convention for serial interfaces—specifically whether the channel-group number is appended to the interface name—is determined by the configuration mode.

The behavior is defined as follows:

- **Partial Timeslots**—If the channel-group is created with partial timeslots (a subset of the 1–31 range), the channel number is appended to the interface name.

  Example: Serial0/9/18.8:0

- **Full Timeslots**—If the channel-group is created with the full range of timeslots (1–31), the channel number is not appended to the interface name.

  Example: Serial0/9/18.1

- **Unframed Mode**—If the channel-group is created in unframed mode, the channel number is appended to the interface name.

  Example: Serial0/3/19.15:0

- **Concatenation Mode** If the channel-group is created in concatenation mode, the channel number is not appended to the interface name.

  Example: Serial0/3/17.1

Verifying T1 or E1 Parameters Configuration

Use **show running-configuration** command to verify T1 or E1 parameters configuration:

```
#show running-configuration
controller SDH 0/0/16
rate STM1
no ais-shut
alarm-report all
clock source internal
overhead s1s0 0
aug mapping au-4
au-4 1
clock source internal
mode tug-3
tug-3 2
mode VC1x
tug-2 1 payload VC11
t1 1 loopback network line
t1 1 clock source line
```

SDH T3/E3 Configuration Parameters

The following parameters affect SDH T3/E3 configuration:

- **Clock** — Specifies the clock source for T3 or E3 link.
- **Loopback** — Sets the T3 or E3 link in the loopback mode.
- **CEM Group** — Creates a circuit emulation (CEM) channel from one or more time slots of a T1 or E1 line.
- **BERT** — Bit-Error Rate Testing (BERT) is used for analyzing quality and for problem resolution of digital transmission equipment.

Configuring SDH T3/E3 Parameters Configuration

To configure SDH T3/E3 parameters configuration:

```
enable
configure terminal
controller sdh 0/0/16
rate stm4
au-4 1
mode tug 3
tug-3 1
mode e3
e3 1 clock source [line | internal | recovered]
e3 framing [m13 | c-bit ] (applicable to for mode e3)
e3 1 loopback [local | network line]
e3 bert pattern 0s interval 2
tug-3 2
mode t3
t3 1 clock source [line | internal | recovered]
t3 framing [m13 | c-bit ] (applicable to for mode t3)
t3 1 loopback [local | network line]
t3 bert pattern 0s interval 2
end
```

Note This is applicable to AUG mappaing AU-4 mode T3 and AU-3 mode T3.

Verifying SDH T3 or E3 Parameters Configurations

Use **show running-configuration** command to verify SDH T3 or E3 parameters configurations:

```
# show running-configuration
controller sdh 0/0/16
rate stm1
au-4 2
mode tug-3
clock source internal
tug-3 1
mode E3
threshold b3-tca 0
overhead c2 0
e3 clock source internal
e3 framing g751
!tug-3 2mode T3
threshold b3-tca 0
overhead c2 0
t3 clock source internal
t3 framing c-bit!
```

SDH VC Configuration Parameters for SAToP

The following parameters affect SDH VC configuration:

- **BERT** — Starts the BERT test.
- **CEM Group** — Specifies the time slots for CEM group mapping.

- **Clock** — Specifies the clock source for VC.
- **Loopback** — Sets the VC in the loopback mode.
- **Overhead** — Configures VC line path overhead flags.
- **Shutdown** — Disables the VC interface.

Configuring VC Parameters

To configure VC parameters:

```
enable
configure terminal
controller sdh 0/0/16
rate stm4
au-3 1
mode vc1x
tug-2 1 payload vc11
vc 1 loopback [local | network]
vc 1 clock source internal
vc 1 overhead j2 expected [16  | 64]
vc 1 overhead j2 expected message STRING
vc 1 overhead j2 tx [16  | 64]
vc 1 overhead j2 tx message STRING
vc 1 overhead v5 [0 - 7]
vc 1 [threshold bip2-sd 4 | threshold bip2-sf  4 | threshold bip2-tca 9]
end
```

Note v5 overhead should match with the far end tx v5.

Verifying VC Configuration Parameters Configurations

Use **show running-configuration** command to verify VC configuration parameters configuration:

```
#show running-configuration
controller SDH 0/0/16
rate STM1
no ais-shut
alarm-report all
clock source internal
overhead s1s0 0
aug mapping au-4
au-4 1
clock source internal
mode tug-3
tug-3 1
mode VC1x
tug-2 1 payload VC11
vc 1 overhead j2 tx message STRING
vc 1 overhead j2 expected message STRING
vc 1 threshold bip2-sd 4
vc 1 threshold bip2-sf 4
vc 1 threshold bip2-tca 9
```

Configuring ACR on SDH

To configure E1 ACR:

```
enable
configure terminal
controller sdh 0/0/16
rate STM1
no ais-shut
alarm-report all
clock source internal
overhead s1s0 0
aug mapping au-4
au-4 1
clock source internal
mode tug-3
tug-3 1
mode vc1x
tug-2 1 payload vc12
e1 1 cem-group 1 unframed
e1 1 clock source recovered 1
tug-2 2 payload vc11
tug-2 3 payload vc11
tug-2 4 payload vc11
end
```

To configure E3 ACR:

```
enable
configure terminal
controller sdh 0/0/16
rate STM1
no ais-shut
alarm-report all
clock source internal
overhead s1s0 0
aug mapping au-4
au-4 1
clock source internal
mode tug-3
tug-3 1
mode e3
overhead c2 0
cem-group 1 unframed
e3 clock source recovered 1
```

ACR Global Configuration

```
enable
configure terminal
recovered-clock 0 4
clock recovered 1 adaptive cem 0 1
end
```

Verifying ACR Configuration on SDH

Use **show recovered clock** command to verify E1 ACR configuration:

```
#show recovered clock
Recovered clock status for subslot 0/16
```

```
----------------------------------------
Clock    Type      Mode         CEM    Status    Frequency Offset(ppb)  Circuit-No
1        STMx-E1  ADAPTIVE      1    ACQUIRED   n/a                    0/1/1/1/1
(Port/au-4/tug3/tug2/e1)
```

Use **show recovered clock** command to verify T3 ACR configuration:

```
#show recovered clock
Recovered clock status for subslot 0/16
----------------------------------------
Clock    Type      Mode         CEM    Status    Frequency Offset(ppb)  Circuit-No
1        STMx-E3  ADAPTIVE      1    ACQUIRED   n/a                   0/1/1 (Port/au-4/tug3)
```

Configuring DCR on SDH

To configure E1 DCR:

```
enable
configure terminal
controller sdh 0/0/16
rate STM1
no ais-shut
alarm-report all
clock source internal
overhead s1s0 0
aug mapping au-4
au-4 1
clock source internal
mode tug-3
tug-3 1
mode vc1x
tug-2 1 payload vc12
e1 1 cem-group 1 unframed
e1 1 clock source recovered 1
tug-2 2 payload vc11
tug-2 3 payload vc11
tug-2 4 payload vc11
end
```

To configure E3 DCR:

```
enable
configure terminal
controller sdh 0/0/16
rate STM1
no ais-shut
alarm-report all
clock source internal
overhead s1s0 0
aug mapping au-4
au-4 1
clock source internal
mode tug-3
tug-3 1
mode e3
overhead c2 0
cem-group 1 unframed
e3 clock source recovered 1
```

DCR Global Configuration

```
enable
configure terminal
recovered-clock 0 4
clock recovered 1 differential cem 0 1
end
```

Verifying DCR Configuration on SDH

Use **show recovered clock** command to verify E1 DCR configuration:

```
#show recovered clockRecovered clock status for subslot 0/16
----------------------------------------
Clock    Type     Mode          CEM    Status    Frequency Offset(ppb)  Circuit-No
1        STMx-E1  DIFFERENTIAL     1    ACQUIRED   n/a                    0/1/1/1/1
(Port/au-4/tug3/tug2/e1)
```

Use **show recovered clock** command to verify T3 DCR configuration:

```
#show recovered clock
Recovered clock status for subslot 0/16
----------------------------------------
Clock    Type     Mode         CEM    Status    Frequency Offset(ppb)  Circuit-No
1        STMx-E3  DIFFERENTIAL     1    ACQUIRED   n/a                    0/1/1
(Port/au-4/tug3)
```

Loopback Remote on T1 and T3 Interfaces

The remote loopback configuration attempts to put the far-end T1 or T3 into a loopback.

The remote loopback setting loops back the far-end at line or payload, using IBOC (inband bit-orientated CDE) or the ESF loopback codes to communicate the request to the far-end.

Restrictions for Loopback Remote

- E1 and E3 loopback remote are not supported until Cisco IOS XE Fuji 16.9.4 release. Starting from Cisco IOS XE Fuji 16.9.5 release, E1 and E3 loopback remote are supported.
- IBOC loopcode configuration is not supported when CESoP or SATOP (framed or unframed) is configured.
- ESF loopcode configuration is not supported when SAToP is configured.

Configuring Loopback Remote in SDH

To set T1 loopback remote iboc fac1/fac2/csu for OCX in SDH, perform the following tasks in global configuration mode:

```
enable
configure terminal
controller sdh 0/2/0
mode vc1x
tug-2 1 payload vc1x
t1 1 loopback remote iboc {fac1 | fac2 | csu}
```

To set T1 loopback remote iboc esf line csu/esf payload for OCX in SDH, perform the following tasks in global configuration mode:

```
enable
configure terminal
controller sdh 0/2/0
mode vc1x
tug-2 1 payload vc1x
t1 1 loopback remote esf {line csu | payload}
```

To set T3 loopback remote line/payload for OCX in SDH, perform the following tasks in global configuration mode:

```
enable
configure terminal
controller sdh 0/2/0
mode t3
t3 loopback remote {line | payload}
```



Note **loopback remote esf line niu** is not supported.

Verifying the Loopback Remote Configuration

Use the following command to check the T1 loopback remote configuration:

```
router# show run | sec 0/2/0
controller SDH 0/2/0
rate STM1
no ais-shut
alarm-report all
clock source internal
overhead s1s0 0
aug mapping au-4
au-4 1
  clock source internal
 mode tug-3
  tug-3 1
   mode VC1x
   tug-2 1 payload VC11
    t1 1 Loopback remote iboc fac1
```

Use the following command to verify the T1 loopback remote configuration:

```
Router(config-ctrlr-tug2-vcx)#do show controller sdh 0/2/0 | be T1 1
AU-4 1, TUG-3 1, TUG-2 1, T1 1 (C-11 1/1/1/1) is up
  timeslots:
  Configured for NIU FAC1 Line Loopback with IBOC
  Currently in Inband Remotely Line Looped
  Receiver has no alarms.
  Framing is SF, Clock Source is Internal
  Data in current interval (250 seconds elapsed):
   Near End
     0 Line Code Violations, 0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
     0 Unavailable Secs, 0 Stuffed Secs
     0 Path Failures, 0 SEF/AIS Secs
   Far End
     0 Line Code Violations, 0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
```

```
    0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
    0 Unavailable Secs 0 Path Failures
  Data in Interval 1:
   Near End
    0 Line Code Violations, 0 Path Code Violations
    0 Slip Secs, 2 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
    2 Errored Secs, 0 Bursty Err Secs, 2 Severely Err Secs
    0 Unavailable Secs, 0 Stuffed Secs
    1 Path Failures, 2 SEF/AIS Secs
   Far End
    0 Line Code Violations, 0 Path Code Violations
    0 Slip Secs, 2 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
    3 Errored Secs, 0 Bursty Err Secs, 3 Severely Err Secs
    0 Unavailable Secs 0 Path Failures
  Total Data (last 1 15 minute intervals):
   Near End
    0 Line Code Violations,0 Path Code Violations,
    0 Slip Secs, 2 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins,
    2 Errored Secs, 0 Bursty Err Secs, 2 Severely Err Secs
    0 Unavailable Secs, 0 Stuffed Secs
    1 Path Failures, 2 SEF/AIS Secs
   Far End
    0 Line Code Violations,0 Path Code Violations
    0 Slip Secs, 2 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins,
    3 Errored Secs, 0 Bursty Err Secs, 3 Severely Err Secs
    0 Unavailable Secs, 0 Path Failures
```

Use the following command to check the T3 loopback remote configuration:

```
Router#show run | sec 0/4/7
platform enable controller MediaType 0/4/7 oc3
controller MediaType 0/4/7
mode sdh
controller SDH 0/4/7
rate STM1
no ais-shut
alarm-report all
clock source internal
overhead s1s0 0
aug mapping au-4
au-4 1
  clock source internal
  mode tug-3
  tug-3 1
   mode T3
   t3 clock source internal
   t3 framing c-bit
   t3 loopback remote line
```

Use the following command to verify the T3 loopback remote configuration:

```
Router#show controll sdh 0/4/7 | be T3
SDH 0/4/7.1/1 T3 is up. (Configured for Remotely Looped)
  Hardware is NCS4200-1T8S-10CS
  Applique type is T3
  Receiver has no alarms.
  Data in current interval (240 seconds elapsed):
   Near End
    0 Line Code Violations, 0 P-bit Coding Violations
    0 C-bit Coding Violations, 0 P-bit Err Secs
    0 P-bit Severely Err Secs, 0 Severely Err Framing Secs
```

```
      0 Unavailable Secs, 0 Line Errored Secs
      0 C-bit Errored Secs, 0 C-bit Severely Errored Secs
      0 Severely Errored Line Secs, 0 Path Failures
      0 AIS Defect Secs, 0 LOS Defect Secs
    Far End
      0 Errored Secs, 0 Severely Errored Secs
      0 C-bit Unavailable Secs, 0 Path Failures
      0 Code Violations, 0 Service Affecting Secs
  Data in Interval 1:
   Near End
      0 Line Code Violations, 0 P-bit Coding Violations
      0 C-bit Coding Violations, 0 P-bit Err Secs
      0 P-bit Severely Err Secs, 0 Severely Err Framing Secs
      20 Unavailable Secs, 20 Line Errored Secs
      0 C-bit Errored Secs, 0 C-bit Severely Errored Secs
      20 Severely Errored Line Secs, 1 Path Failures
      0 AIS Defect Secs, 20 LOS Defect Secs
    Far End
      0 Errored Secs, 0 Severely Errored Secs
      0 C-bit Unavailable Secs, 0 Path Failures
      0 Code Violations, 0 Service Affecting Secs
  Total Data (last 1 15 minute intervals):
   Near End
      0 Line Code Violations, 0 P-bit Coding Violations,
      0 C-bit Coding Violations, 0 P-bit Err Secs,
      0 P-bit Severely Err Secs, 0 Severely Err Framing Secs,
      20 Unavailable Secs, 20 Line Errored Secs,
      0 C-bit Errored Secs, 0 C-bit Severely Errored Secs
      20 Severely Errored Line Secs, 1 path failures
      0 AIS Defect Secs, 20 LOS Defect Secs
    Far End
      0 Errored Secs, 0 Severely Errored Secs
      0 C-bit Unavailable Secs, 0 Path Failures
      0 Code Violations, 0 Service Affecting Secs

T1 1 is up
  timeslots:
  FDL per AT&T 54016 spec.
  No alarms detected.
  Framing is ESF, Clock Source is Internal
  Data in current interval (250 seconds elapsed):
   Near End
      0 Line Code Violations, 0 Path Code Violations
      0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
      0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
      0 Unavailable Secs, 0 Stuffed Secs
      0 Path Failures, 0 SEF/AIS Secs
    Far End
      0 Line Code Violations, 0 Path Code Violations
      0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
      0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
      0 Unavailable Secs 0 Path Failures
  Data in Interval 1:
   Near End
      0 Line Code Violations, 0 Path Code Violations
      0 Slip Secs, 2 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
      2 Errored Secs, 0 Bursty Err Secs, 2 Severely Err Secs
      0 Unavailable Secs, 0 Stuffed Secs
      1 Path Failures, 2 SEF/AIS Secs
    Far End
      0 Line Code Violations, 0 Path Code Violations
      0 Slip Secs, 2 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
      3 Errored Secs, 0 Bursty Err Secs, 3 Severely Err Secs
      0 Unavailable Secs 0 Path Failures
```

```
  Total Data (last 1 15 minute intervals):
   Near End
     0 Line Code Violations,0 Path Code Violations,
     0 Slip Secs, 2 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins,
     2 Errored Secs, 0 Bursty Err Secs, 2 Severely Err Secs
     0 Unavailable Secs, 0 Stuffed Secs
     1 Path Failures, 2 SEF/AIS Secs
   Far End
     0 Line Code Violations,0 Path Code Violations
     0 Slip Secs, 2 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins,
     3 Errored Secs, 0 Bursty Err Secs, 3 Severely Err Secs
     0 Unavailable Secs, 0 Path Failures
```

Performance Monitoring Use Cases or Deployment Scenarios for SDH

Starting with Cisco IOS XE 17.11.1, you can view the previous day performance monitoring details using the following **show controller** commands for the T1 or E1, T3 or E3, and SDH controllers.

- show controllers sdh
- show controllers sdh tabular
- show controllers sdh remote performance
- show controllers sdh remote performance tabular

```
router#show controllers sdh 0/4/0

SDH 0/4/0 is down.
  Hardware is A900-IMA1Z8S-CX

 Port configured rate: STM1
 Applique type is Channelized SDH
 Clock Source is Internal, AUG mapping is AU4.
Medium info:
  Type: SDH, Line Coding: NRZ,
 Alarm Throttling: OFF
 Regenerator Section:
  LOS = 1          LOF = 0                            BIP(B1) = 0

SDH Section Tables
  INTERVAL       CV    ES   SES  SEFS
  06:14-06:27     0   821   821   821
  05:59-06:14     0   901   901   901
  05:44-05:59     0   901   901   901
.............
  06:59-07:14     0   901   901   901
  06:44-06:59     0   901   901   901
  06:29-06:44     0   901   901   901
  06:14-06:29     0   901   901   901
Total of Data in Current and Previous Intervals
  06:14-06:27     0 87317 87317 87317
Total (Previous Day)
  05:29-05:29     0 86494 86494 86494

Multiplex Section:
```

```
.............
SDH Line Tables
  INTERVAL       CV    ES   SES   UAS  CVFE  ESFE  SESFE  UASFE
  06:14-06:27     0     0     0   821     0     0      0      0
  05:59-06:14     0     0     0   901     0     0      0      0
  05:44-05:59     0     0     0   901     0     0      0      0
..............
  06:29-06:44     0     0     0   901     0     0      0      0
  06:14-06:29     0     0     0   901     0     0      0      0
Total of Data in Current and Previous Intervals
  06:14-06:27     0     0     0 87317     0     0      0      0
Total (Previous Day)
  05:29-05:29     0     0     0 86494     0     0      0      0


High Order Path:

PATH 1:
Clock Source is internal

  AIS = 0          RDI = 0          REI = 0          BIP(B3) = 0
  LOM = 0          PLM = 0          UNEQ = 0          LOP = 0

Active Defects: None
Detected Alarms: PAIS LOM
.............

SDH Path Tables
  INTERVAL       CV    ES   SES   UAS  CVFE  ESFE  SESFE  UASFE
  06:14-06:27     0     0     0   820     0     0      0      0
  05:59-06:14     0     0     0   900     0     0      0      0
  05:44-05:59     0     0     0   900     0     0      0      0
  05:29-05:44     0     0     0   901     0     0      0      0
  05:14-05:29     0     0     0   900     0     0      0      0
  04:59-05:14     0     0     0   900     0     0      0      0
  04:44-04:59     0     0     0   901     0     0      0      0
..............
  06:14-06:29     0     0     0   900     0     0      0      0
Total of Data in Current and Previous Intervals
  06:14-06:27     0     0     0 87256     0     0      0      0
Total (Previous Day)
  05:29-05:29     0     0     0 86448     0     0      0      0


 AU-4 1, TUG-3 1, TUG-2 1, VC12 1 (SDH 0/4/0.1/1/1/1 VC12) is down
 VT Receiver has LP_AIS.
  cep is configured: FALSE cem_id  (0)
  fwd_alarm_ais :0    fwd_alarm_rai :0, Clock Source is Internal
  BIP2-tca:6, BIP2-sf:3, BIP2-sd:6
  Tx V5:2
  Rx V5:0
  Tx J2 Length=16
  TX J2 Trace Buffer:
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

  Expected J2 Length=16
  Expected J2 Trace Buffer:
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

  Rx J2 Length=16
  RX J2 Trace Buffer:
  CRC-7: 0xDA ERROR

  54 53 1F 0F 6C 2C 27 B1 E8 0A 0D 88 5D 03 09 00     TS..l,'.....]...
```

```
 Data in curerent interval (820 seconds elapsed)
   Near End
    0 CodeViolations, 0 ErrorSecs, 0 Severly Err Secs, 820 Unavailable Secs
   Far End
    0 CodeViolations, 0 ErrorSecs, 0 Severly Err Secs, 0 Unavailable Secs
 Data in Interval 1:
   Near End
    0 CodeViolations, 0 ErrorSecs, 0 Severly Err Secs, 900 Unavailable Secs
   Far End
    0 CodeViolations, 0 ErrorSecs, 0 Severly Err Secs, 0 Unavailable Secs
 Data in Interval 2:
   Near End
.................
 Data in Interval 96:
   Near End
    0 CodeViolations, 0 ErrorSecs, 0 Severly Err Secs, 900 Unavailable Secs
   Far End
    0 CodeViolations, 0 ErrorSecs, 0 Severly Err Secs, 0 Unavailable Secs
 Total Data (last 96 fifteen minute intervals):
   Near End
    0 CodeViolations, 0 ErrorSecs, 0 Severly Err Secs, 86436 Unavailable Secs
   Far End
    0 CodeViolations, 0 ErrorSecs, 0 Severly Err Secs, 0 Unavailable Secs
 Total (Previous Day):
   Near End
    0 CodeViolations, 0 ErrorSecs, 0 Severly Err Secs, 86436 Unavailable Secs
   Far End
    0 CodeViolations, 0 ErrorSecs, 0 Severly Err Secs, 0 Unavailable Secs


 AU-4 1, TUG-3 1, TUG-2 1, E1 1 (SDH 0/4/0.1/1/1/1 E1) is down
  timeslots: 1-16
  Receiver is getting AIS.
  Framing is crc4, Clock Source is Internal, National bits are 0x1F.
  Data in current interval (820 seconds elapsed):
   Near End
     0 Line Code Violations, 0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
     820 Unavail Secs, 0 Stuffed Secs
.....................
   Data in Interval 96:
   Near End
     0 Line Code Violations, 0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
     900 Unavail Secs, 0 Stuffed Secs
   Far End
     0 Line Code Violations, 0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
     0 Unavail Secs
  Total Data (last 24 hours)
   Near End
     0 Line Code Violations,0 Path Code Violations,
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins,
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
     86436 Unavail Secs, 0 Stuffed Secs
   Far End
     0 Line Code Violations,0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins,
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
     0 Unavailable Secs
```

```
  Total (Previous Day)
   Near End
     0 Line Code Violations,0 Path Code Violations,
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins,
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
     86436 Unavail Secs, 0 Stuffed Secs
   Far End
     0 Line Code Violations,0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins,
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
     0 Unavailable Secs

 AU-4 1, TUG-3 1, TUG-2 1, VC12 2 (SDH 0/4/0.1/1/1/2 VC12) is down
 VT Receiver has LP_AIS.


router#show controllers sdh 0/4/0 tabular
  Section, Line, Path as Previous.
  AU-4 1, TUG-3 1, TUG-2 1, VC12 1 (SDH 0/4/0.1/1/1/1 VC12) is down
 VT Receiver has LP_AIS.
  cep is configured: FALSE cem_id  (0)
  fwd_alarm_ais :0    fwd_alarm_rai :0, Clock Source is Internal
  BIP2-tca:6, BIP2-sf:3, BIP2-sd:6
  Tx V5:2
  Rx V5:0
  Tx J2 Length=16
  TX J2 Trace Buffer:
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

  Expected J2 Length=16
  Expected J2 Trace Buffer:
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

  Rx J2 Length=16
  RX J2 Trace Buffer:
  CRC-7: 0xDA ERROR

  54 53 1F 0F 6C 2C 27 B1 E8 0A 0D 88 5D 03 09 00     TS..l,'.....]...

 INTERVAL     CV-V  ES-V  SES-V  UAS-V  CV-VFE  ES-VFE  SES-VFE  UAS-VFE
 06:14-06:27     0     0      0    830       0       0        0        0
 05:59-06:14     0     0      0    900       0       0        0        0
 05:44-05:59     0     0      0    900       0       0        0        0
.....................
 06:44-06:59     0     0      0    900       0       0        0        0
 06:29-06:44     0     0      0    901       0       0        0        0
 06:14-06:29     0     0      0    900       0       0        0        0
 Total           0     0      0  86436       0       0        0        0
 Total (Previous Day)
 05:29-05:29     0     0      0  86436       0       0        0        0


 AU-4 1, TUG-3 1, TUG-2 1, E1 1 (SDH 0/4/0.1/1/1/1 E1) is down
  timeslots: 1-16
  Receiver is getting AIS.
  Framing is crc4, Clock Source is Internal, National bits are 0x1F.
  Near End Data
  INTERVAL     CV-L   ES-L   CV-P   ES-P  SES-P  CSS-P  SAS-P  UAS-P   FC-P
  06:14-06:27     0      0      0      0      0      0      0    830      0
  05:59-06:14     0      0      0      0      0      0      0    900      0
  05:44-05:59     0      0      0      0      0      0      0    900      0
  05:29-05:44     0      0      0      0      0      0      0    901      0
.....................
  06:44-06:59     0      0      0      0      0      0      0    900      0
  06:29-06:44     0      0      0      0      0      0      0    901      0
```

```
  06:14-06:29     0      0      0      0      0      0      0    900       0
  Total           0      0      0      0      0      0      0  86436       0
  Total (Previous Day)
  05:29-05:29     0      0      0      0      0      0      0  86436       0
  Far End Data
  INTERVAL     ES-LFE  ES-PFE  SES-PFE  SEFS-PFE  CSS-PFE  UAS-PFE  FC-PFE
  06:14-06:27       0       0        0         0        0        0       0
  05:59-06:14       0       0        0         0        0        0       0
.....................
  06:29-06:44       0       0        0         0        0        0       0
  06:14-06:29       0       0        0         0        0        0       0
  Total             0       0        0         0        0        0       0
  Total (Previous Day)
  05:29-05:29       0       0        0         0        0        0       0

 AU-4 1, TUG-3 1, TUG-2 1, VC12 2 (SDH 0/4/0.1/1/1/2 VC12) is down
 VT Receiver has LP_AIS.
  cep is configured: FALSE cem_id  (0)
  fwd_alarm_ais :0    fwd_alarm_rai :0, Clock Source is Internal


router#show controllers sdh 0/4/0 remote performance

Section, Line and Path as Previous.

 STS-1 1, VTG 1, VT 1 (VT1.5 1/1/1) - Remote Performance Data
 Far end MIB Data:
 Data in curerent interval (840 seconds elapsed)
 0 CodeViolations , 0 ErrorSecs,0 Severly Err Secs, 0 Unavail Secs
 FarEnd VT Interval data:
 Total Data (last 96 15 minute intervals):
 0 CodeViolations, 0 ErrorSec,  0 Severly Err Secs, 0 Unavail Secs

 Total (Previous Day):
 0 CodeViolations, 0 ErrorSec,  0 Severly Err Secs, 0 Unavail Secs

 AU-4 1, TUG-3 1, TUG-2 1, E1 1 (SDH 0/4/0.1/1/1/1 E1) - Remote Performance Data
  Data in current interval (840 seconds elapsed):
     0 Line Code Violations, 0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
     0 Unavail Secs
  Data in Interval 1:
     0 Line Code Violations, 0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
     0 Errored Secs, 0
.................
  Data in Interval 95:
     0 Line Code Violations, 0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
     0 Unavail Secs
  Data in Interval 96:
     0 Line Code Violations, 0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
     0 Unavail Secs
  Total Data (last 24 hours)
     0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins,
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
     0 Unavail Secs
  Total (Previous Day)
     0 Path Code Violations
     0 Slip Secs, 0 Fr Loss Secs, 0 Line Err Secs, 0 Degraded Mins,
```

```
     0 Errored Secs, 0 Bursty Err Secs, 0 Severely Err Secs
     0 Unavail Secs

 STS-1 1, VTG 1, VT 2 (VT1.5 1/1/2) - Remote Performance Data
 Far end MIB Data:
 Data in curerent interval (840 seconds elapsed)
 0 CodeViolations , 0 ErrorSecs,0 Severly Err Secs, 0 Unavail Secs
 FarEnd VT Interval data:
 Total Data (last 96 15 minute intervals):
 0 CodeViolations, 0 ErrorSec,  0 Severly Err Secs, 0 Unavail Secs

 Total (Previous Day):
 0 CodeViolations, 0 ErrorSec,  0 Severly Err Secs, 0 Unavail Secs


 AU-4 1, TUG-3 1, TUG-2 1, E1 2 (SDH 0/4/0.1/1/1/2 E1) - Remote Performance Data (Not
available)

 STS-1 1, VTG 1, VT 3 (VT1.5 1/1/3) - Remote Performance Data
 Far end MIB Data:


router#show controllers sdh 0/4/0 remote performance tabular

Section, Line and Path as Previous.

 STS-1 1, VTG 1, VT 1 (VT1.5 1/1/1) - Remote Performance Data
 Far end MIB Data:
 INTERVAL       CV     ES    SES   UAS
 06:14-06:28     0     0     0     0
 FarEnd VT Interval data:
 INTERVAL       CV     ES    SES   UAS
  05:59-06:14     0     0     0     0

  05:44-05:59     0     0     0     0

  05:29-05:44     0     0     0     0
..................
  06:29-06:44     0     0     0     0

  06:14-06:29     0     0     0     0

 Total
  CV    ES   SES   UAS    0     0     0     0

 Total (Previous Day)
  CV    ES   SES   UAS    0     0     0     0

 AU-4 1, TUG-3 1, TUG-2 1, E1 1 (SDH 0/4/0.1/1/1/1 E1) - Remote Performance Data
  INTERVAL      LCV   PCV   CSS  SELS   LES    DM    ES   BES   SES   UAS
  06:14-06:28     0     0     0     0     0     0     0     0     0     0
  05:59-06:14     0     0     0     0     0     0     0     0     0     0
..................
  06:44-06:59     0     0     0     0     0     0     0     0     0     0
  06:29-06:44     0     0     0     0     0     0     0     0     0     0
  06:14-06:29     0     0     0     0     0     0     0     0     0     0
  Total           0     0     0     0     0     0     0     0     0     0
  Total (Previous Day)
  05:29-05:29     0     0     0     0     0     0     0     0     0     0

 STS-1 1, VTG 1, VT 2 (VT1.5 1/1/2) - Remote Performance Data
 Far end MIB Data:
 INTERVAL       CV     ES    SES   UAS
 06:14-06:28     0     0     0     0
```

```
router#show controllers sdh 0/4/1
SDH 0/4/1 is down.
  Hardware is A900-IMA1Z8S-CX

 Port configured rate: STM1
 Applique type is Channelized SDH
 Clock Source is Internal, AUG mapping is AU4.
Medium info:
  Type: SDH, Line Coding: NRZ,
 Alarm Throttling: OFF
 Regenerator Section:
  LOS = 1          LOF = 0                          BIP(B1) = 0

SDH Section Tables
  INTERVAL       CV    ES   SES  SEFS
  06:14-06:28     0   841   841   841
  05:59-06:14     0   901   901   901
  05:44-05:59     0   901   901   901
  05:29-05:44     0   901   901   901
..............
  06:44-06:59     0   901   901   901
  06:29-06:44     0   901   901   901
  06:14-06:29     0   901   901   901
Total of Data in Current and Previous Intervals
  06:14-06:28     0 87337 87337 87337
Total (Previous Day)
  05:29-05:29     0 86493 86493 86493

Multiplex Section:
  AIS = 0          RDI = 0          REI = 0          BIP(B2) = 0
Active Defects: None
.............

SDH Line Tables
  INTERVAL       CV    ES   SES   UAS  CVFE  ESFE  SESFE  UASFE
  06:14-06:28     0     0     0   841     0     0      0      0
  05:59-06:14     0     0     0   901     0     0      0      0
  05:44-05:59     0     0     0   901     0     0      0      0
  05:29-05:44     0     0     0   901     0     0      0      0
............
  06:44-06:59     0     0     0   901     0     0      0      0
  06:29-06:44     0     0     0   901     0     0      0      0
  06:14-06:29     0     0     0   901     0     0      0      0
Total of Data in Current and Previous Intervals
  06:14-06:28     0     0     0 87337     0     0      0      0
Total (Previous Day)
  05:29-05:29     0     0     0 86493     0     0      0      0

High Order Path:

PATH 1:
Clock Source is internal

  AIS = 0          RDI = 0          REI = 0          BIP(B3) = 0
  LOM = 0          PLM = 0          UNEQ = 0          LOP = 0
.....................
SDH Path Tables
  INTERVAL       CV    ES   SES   UAS  CVFE  ESFE  SESFE  UASFE
  06:14-06:28     0     0     0   840     0     0      0      0
  05:59-06:14     0     0     0   900     0     0      0      0
  05:44-05:59     0     0     0   900     0     0      0      0
  05:29-05:44     0     0     0   901     0     0      0      0
.....................
```

```
  06:44-06:59     0     0     0   900     0     0      0      0
  06:29-06:44     0     0     0   901     0     0      0      0
  06:14-06:29     0     0     0   900     0     0      0      0
Total of Data in Current and Previous Intervals
  06:14-06:28     0     0     0 87276     0     0      0      0
Total (Previous Day)
  05:29-05:29     0     0     0 86448     0     0      0      0

 Low Order Path 1:
Clock Source is internal

  AIS = 0          RDI = 0          REI = 0          BIP(B3) = 0
  LOM = 0          PLM = 0          UNEQ = 0          LOP = 0
.............
SDH Path Tables
  INTERVAL       CV    ES   SES   UAS  CVFE  ESFE  SESFE  UASFE
  06:14-06:28     0     0     0   840     0     0      0      0
  05:59-06:14     0     0     0   900     0     0      0      0
  05:44-05:59     0     0     0   900     0     0      0      0
  05:29-05:44     0     0     0   901     0     0      0      0
  05:14-05:29     0     0     0   900     0     0      0      0
  04:59-05:14     0     0     0   900     0     0      0      0
  04:44-04:59     0     0     0   901     0     0      0      0
..................
  06:29-06:44     0     0     0   901     0     0      0      0
  06:14-06:29     0     0     0   900     0     0      0      0
Total of Data in Current and Previous Intervals
  06:14-06:28     0     0     0 87276     0     0      0      0
Total (Previous Day)
  05:29-05:29     0     0     0 86435     0     0      0      0

SDH 0/4/1.1/1 E3 is down.
  Hardware is A900-IMA1Z8S-CX

  Applique type is E3
  Receiver is getting AIS.
  Framing is E3 G751, Cablelength is 224
  BER thresholds:  SF = 10e-3  SD = 10e-6
  Clock Source is internal, National Bit 0
  Equipment customer loopback
  Data in current interval (840 seconds elapsed):
   Near End
     0 Line Code Violations, 0 P-bit Coding Violation
     0 C-bit Coding Violation, 0 P-bit Err Secs
     0 P-bit Severely Err Secs, 0 Severely Err Framing Secs
     840 Unavailable Secs, 0 Line Errored Secs
     0 C-bit Errored Secs, 0 C-bit Severely Errored Secs
     0 Severely Errored Line Secs, 0 Path Failures
     0 AIS Defect Secs, 0 LOS Defect Secs
   Far End
     0 Errored Secs, 0 Severely Errored Secs
     0 C-bit Unavailable Secs, 0 Path Failures
     0 Code Violations, 0 Service Affecting Secs
  Data in Interval 1:
..................
   Far End
     0 Errored Secs, 0 Severely Errored Secs
     0 C-bit Unavailable Secs, 0 Path Failures
     0 Code Violations, 0 Service Affecting Secs
  Total Data (last 24 hours)
   Near End
     0 Line Code Violations, 0 P-bit Coding Violation,
     0 C-bit Coding Violation, 0 P-bit Err Secs,
     0 P-bit Severely Err Secs, 0 Severely Err Framing Secs,
```

```
    86436 Unavailable Secs, 0 Line Errored Secs,
    0 C-bit Errored Secs, 0 C-bit Severely Errored Secs
    0 Severely Errored Line Secs, 0 path failures
    0 AIS Defect Secs, 0 LOS Defect Secs
  Far End
    0 Errored Secs, 0 Severely Errored Secs
    0 C-bit Unavailable Secs, 0 Path Failures
    0 Code Violations, 0 Service Affecting Secs
 Total (Previous Day)
  Near End
    0 Line Code Violations, 0 P-bit Coding Violation,
    0 C-bit Coding Violation, 0 P-bit Err Secs,
    0 P-bit Severely Err Secs, 0 Severely Err Framing Secs,
    86448 Unavailable Secs, 0 Line Errored Secs,
    0 C-bit Errored Secs, 0 C-bit Severely Errored Secs
    0 Severely Errored Line Secs, 2 path failures
    0 AIS Defect Secs, 0 LOS Defect Secs
  Far End
    0 Errored Secs, 0 Severely Errored Secs
    0 C-bit Unavailable Secs, 0 Path Failures
    0 Code Violations, 0 Service Affecting Secs

router#show controllers sdh 0/4/1 tabular

Section, Line and Path same as Previous.

SDH 0/4/1.1/1 E3 is down.
  Hardware is A900-IMA1Z8S-CX

  Applique type is E3
  Receiver is getting AIS.
  Framing is E3 G751, Cablelength is 224
  BER thresholds:  SF = 10e-3  SD = 10e-6
  Clock Source is internal, National Bit 0
  Equipment customer loopback
  Near End Data
  INTERVAL      CV-L  ES-L  SES-L LOSS-L  CVP-P CVCP-P  ESP-P ESCP-P SESP-P SESCP-P  SAS-P
 AISS-P  FC-P UASP-P UASCP-P
  06:14-06:28      0     0      0      0      0      0      0      0      0       0       0
      0     0    850       0
  05:59-06:14      0     0      0      0      0      0      0      0      0       0       0
      0     0    900       0
  05:44-05:59      0     0      0      0      0      0      0      0      0       0       0
      0     0    900       0
.................
  06:59-07:14      0     0      0      0      0      0      0      0      0       0       0
      0     0    900       0
  06:44-06:59      0     0      0      0      0      0      0      0      0       0       0
      0     0    900       0
  06:29-06:44      0     0      0      0      0      0      0      0      0       0       0
      0     0    901       0
  06:14-06:29      0     0      0      0      0      0      0      0      0       0       0
      0     0    900       0
  Total            0     0      0      0      0      0      0      0      0       0       0
      0     0  86436       0
  Total (Previous Day)
                   0     0      0      0      0      0      0      0      0       0       0
      0     2  86448       0
  Far End Data
  INTERVAL      CVCP-PFE  ESCP-PFE  SESCP-PFE  UASCP-PFE  FCCP-PFE  SASCP-PFE
  06:14-06:28          0         0          0          0         0          0
  05:59-06:14          0         0          0          0         0          0
.....................
  06:59-07:14          0         0          0          0         0          0
```

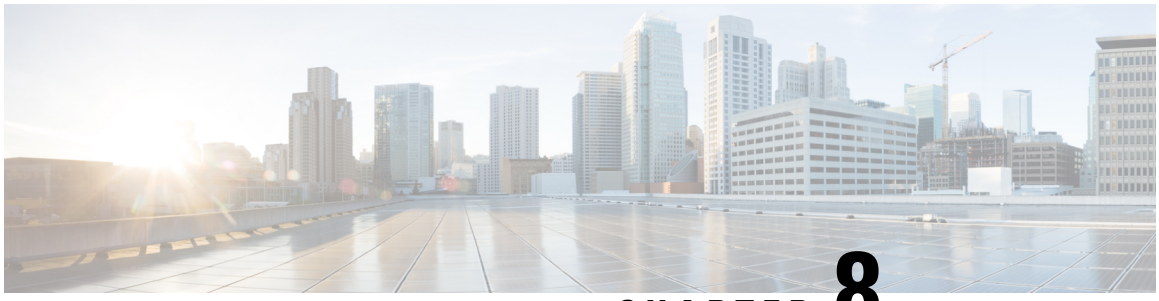
```
06:44-06:59          0          0          0          0          0          0
06:29-06:44          0          0          0          0          0          0
06:14-06:29          0          0          0          0          0          0
Total                0          0          0          0          0          0
Total (Previous Day)
05:29-05:29          0          0          0          0          0          0
```



PART III

Interworking Multiservice Gateway

- Serial Interfaces, on page 145
- Interworking Multiservice Gateway Access Circuit Redundancy, on page 185
- Multilink Interfaces, on page 199
- QoS on Layer 3 Terminated MLPPP Interfaces, on page 225
- VLAN Handoff, on page 233



CHAPTER 8

Serial Interfaces

You can create the serial interface on T1 or E1, T3 or E3, SDH, or SONET interface. Each serial interface configuration differs based on the interface mode.

The channel identifier configuration differs based on the interface mode. For more information, refer serial interface supported modes.

- Serial Interface Supported Modes, on page 145
- Interworking Multiservice Gateway Support Matrix, on page 149
- Creating T1 or E1 Serial Interfaces on T1 or E1 Ports, on page 151
- Creating T3 or E3 Serial Interfaces on T3 or E3 Ports, on page 152
- Creating an E1 Serial Interface in Unframed Mode, on page 153
- Creating Serial Interfaces on SDH, on page 154
- Creating Serial Interfaces on SONET, on page 156
- Modifying Encapsulation to PPP, on page 157
- IPv4 or IPv6 Interworking Multiservice Gateway Pseudowire over HDLC or PPP, on page 158
- IPv4 or IPv6 Interworking Multiservice Gateway Pseudowire over Frame Relay, on page 164
- IPv4 Layer 3 Termination on HDLC or PPP Serial Interfaces, on page 179
- QoS Support on Serial Interfaces, on page 181

Serial Interface Supported Modes

The serial interface name is specified as **interface serial***0/bay/port*. The zero specifies the slot number, bay specifies the bay number in the slot, and port specifies the port number in the bay.

The channel identifier varies depending on port type and supported port modes.

The following table details the values for the channel ID depending on the port modes:

Table 17: Channel Identifier Supported on T1 or E1 Interface

Mode	Interface	Serial Interface with supported Channel Identifier
T1 or E1	T1 or E1	Serial0/bay/port.1 The port value ranges from 0 to 11.

Table 18: Channel Identifier Supported on T3 or E3 Interface

Mode	Interface	Serial Interface with supported Channel Identifier
T3 or E3	T3 or E3	Serial0/bay/port.1 The port value ranges from 12 to 15.
CT3 or CE3	Channelized T3 or E3	Serial0/bay/port.<t1 number> Serial0/bay/port.<e1 number> T1 or E1 number specifies the VTG number with TUG number and T1 channels. The T1 or E1 number that is supported are as follows: • VTG 1/TUG2 1: T1 {1,8,15,22} • VTG 2/TUG2 2: T1 {2,9,16,23} • VTG 3/TUG2 3: T1 {3,10,17,24} • VTG 4/TUG2 4: T1 {4,11,18,25} • VTG 5/TUG2 5: T1 {5,12,19,26} • VTG 6/TUG2 6: T1 {6,13,20,27} • VTG 7/TUG2 7: T1 {7,14,21,28

Table 19: Channel Identifier Supported on SDH or SONET Interface

Mode	Interface Mode	Serial Interface with supported Channel Identifier
SONET or SDH	STS-3c or VC-4	Serial0/bay/port.<channel-id> For SONET, the <channel-id> is calculated based on the following formula: Channel-id = (start_sts_number − 1) x 28 + 1 For SDH, the <channel-id> is calculated based on the following formula: Channel-id = (start_aug4 − 1) x 28 x 3 + 1
SONET or SDH	T3 or E3	Serial0/bay/port.<channel-id> For SONET, the <channel-id> is calculated based on the following formula: Channel-id = (start_sts_number − 1) x 28 + 1 For SDH AU-4 mapping in TUG3 mode, the <channel-id> is calculated based on the following formula: Channel-id = (AUG 4 − 1) x 28 x 3 + (TUG 3 − 1) x 28 + (e1 − 1) x 7 + TUG 2 For SDH AU-3 mapping, the <channel-id> is calculated based on the following formula: Channel-id = (AUG 3 − 1) x 28 + (e1 − 1) x 7 + TUG 2

Mode	Interface Mode	Serial Interface with supported Channel Identifier
SONET or SDH	Concatenated Mode	For SONET, the <channel-id> is calculated based on the following formula: Channel-id = (start_sts_number − 1) x 28 + 1 For SDH, the <channel-id> is calculated based on the following formula: Channel-id = (start_aug4 −1) x 28 x 3 + 1

SONET	VT1.5	Serial0/bay/port.<channel-id>
		<channel-id> is the channel ID calculated based on the following formula:
		Channel-id = (sts_number − 1) x 28 + (T1/E1 − 1) x 7 + VTG
		The following example describes how the channel ID is calculated for a given configuration.
		`sts-1 2`
		`mode vt-15`
		`vtg 2 t1 3 channel-group 0 timeslots 1-24`
		Inter serial interface channel-id = (2 − 1) x 28 + (3 − 1) x 7 + 2 = 44
		• VTG 1 1: T1 {1,8,15,22}
		• VTG 2 2: T1 {2,9,16,23}
		• VTG 3 3: T1 {3,10,17,24}
		• VTG 4 4: T1 {4,11,18,25}
		• VTG 5 5: T1 {5,12,19,26}
		• VTG 6 6: T1 {6,13,20,27}
		• VTG 7 7: T1 {7,14,21,28

SONET	CT3	For the CT3 mode, the <channel-id> is calculated based on the following formula: ((STS - 1) x 28) + T1

Mode	Interface Mode	Serial Interface with supported Channel Identifier
SDH	AU4-T3 or E3	For the SDH AU4-T3 or E3 mode, the <channel-id> is calculated based on the following formula: ((AU Mapping - 1) x 28 x 3) + ((TUG3 - 1) x 28) + 1
SDH	Vc11 and Vc12	T1 number with Vc11 supported: • TUG2 1: T1 {1,8,15,22} • TUG2 2: T1 {2,9,16,23} • TUG2 3: T1 {3,10,17,24} • TUG2 4: T1 {4,11,18,25} • TUG2 5: T1 {5,12,19,26} • TUG2 6: T1 {6,13,20,27} • TUG2 7: T1 {7,14,21,28 E1 number with Vc12 supported: • TUG2 1: E1 {1,8,15} • TUG2 2: E1 {2,9,16} • TUG2 3: E1 {3,10,17} • TUG2 4: E1 {4,11,18} • TUG2 5: E1 {5,12,19} • TUG2 6: E1 {6,13,20} • TUG2 7: E1 {7,14,21} **Note** Depending on the mode selected, the number of E1 changes.



Note ACL is not supported on serial interfaces.

Interworking Multiservice Gateway Support Matrix

The following table details the list of interworking multiservice gateway features supported on Cisco ASR 900 platforms.

Table 20: Interworking Multiservice Gateway Support Matrix on Cisco ASR 900 Platforms

Platform RSP	ASR900-RSP3				ASR900-RSP	
IM Type	A900-IMA3G-IMSG		A900-IMA1Z8S-CXMS		A900-IMA3G-IMSG	
Feature List	IPv4	IPv6	IPv4	IPv6	IPv4	IPv6
Interworking	Y	Y	Y	Y	Y	Y
Interworking Access Circuit Redundancy (ACR)	Y	Y	Y	Y	Y	Y
Interworking UPSR (Only HDLC)	Y	N	Y	N	N	N
L3 Termination (FR & MLFR not supported)	Y	Y	Y	Y	N	N
Interworking nXDS0	Y	N	Y	N	Y	N
Interworking nXDS0 ACR	Y	N	Y	N	Y	N
VLAN Handoff (Local connect)	Y	Y	Y	Y	N	N
VLAN Handoff (Cross connect / Xconnect)	Y	Y	Y	Y	N	N
Interworking MLPPP	Y	Y	Y	Y	Y	Y
Interworking MLPPP ACR	Y	Y	Y	Y	Y	Y
Interworking FR	Y	Y	Y	Y	Y	Y
Interworking MLFR	Y	Y	Y	Y	Y	Y

Platform RSP	ASR900-RSP3				ASR900-RSP	
Interworking FR ACR	Y	Y	Y	Y	Y	Y
Interworking MLFR ACR	Y	Y	Y	Y	Y	Y
L3 QoS (FR & MLFR not supported)	Y	N	Y	N	N	N

Y— Supported

N—Not Supported

Creating T1 or E1 Serial Interfaces on T1 or E1 Ports

Creating T1 Serial Interface

To create a channel group on a T1 interface, use the following commands:

```
router(config)#controller t1 0/2/0
router(config-controller)#channel-group 0  timeslots 1-24
```

Note For T1, the channel-group ID ranges from 0 to 23.

Creating E1 Serial Interface

To create a channel group on an E1 interface, use the following commands:

```
router(config)#controller e1 0/2/0
router(config-controller)#channel-group 0  timeslots 1-31
```

Note For E1, the channel-group ID ranges from 0 to 30.

The following example explains a channel group of number 2 with time slot 1-24 is configured on the T1 interface of the controller. The default encapsulation of HDLC is used.

```
router(config)#controller t1 0/2/0
router(config-controller)#channel-group  2 timeslots  1-24
router(config-controller)#end
```

Note While specifying time slot, use the complete range, for example, 1-24 for T1 and 1-31 for E1.

The following example explains a channel group of number 10 with time slot 1-31 is configured on the E1 interface of the controller. The default encapsulation of HDLC is used.

```
router(config)#controller e1 0/3/2
router(config-controller)#channel-group 10 timeslots 1-31
router(config-controller)#end
```

Creating T3 or E3 Serial Interfaces on T3 or E3 Ports

Configuring Mode to T3 or E3

To configure T3 mode, use the following commands:

```
router(config)#controller mediatype 0/2/12
router(config-controller)#mode t3
router(config-controller)#exit
```

To configure E3 mode, use the following commands:

```
router(config)#controller mediatype 0/2/12
router(config-controller)#mode e3
router(config-controller)#exit
```

Creating T3 Serial Interface

To create a T3 interface, use the following commands:

```
router(config)#controller t3 0/2/12
router(config-controller)#no channelized
router(config-controller)#channel-group 0
router(config-controller)#exit
```



Note Use **no channel group** command to clear configured T3 channels.

Creating E3 Serial Interface

To create an E3 interface, use the following commands:

```
router(config)#controller e3 0/2/12
router(config-controller)#no channelized
router(config-controller)#channel-group 0
router(config-controller)#exit
```



Note Unframed mode is not supported on E3-E1 mode.

Creating CT3 Serial Interface

To create a CT3 interface, use the following commands:

```
router(config)#controller t3 0/2/12
router(config-controller)#channelized
router(config-controller)#t1 1 channel-group 0 timeslots 1-24
router(config-controller)#t1 2 channel-group 0 timeslots 1-24
router(config-controller)#exit
```

Note While specifying time slot, ensure that you provide the complete time slot, for example 1-24 for T1 interface.

The following example explains a channel group of 0 is configured on the E3 interface of the controller. The default encapsulation of HDLC is used.

```
router(config)#controller e3 0/2/12
router(config-controller)#no channelized
router(config-controller)#channel-group 0
router(config-controller)#end
```

The following example explains a channel group of number 0 is configured on the CT3 interface of the controller. The default encapsulation of HDLC is used.

```
router(config)#controller t3 0/2/12
router(config-controller)#no channelized
router(config-controller)#channel-group 0
router(config-controller)#end
```

Creating an E1 Serial Interface in Unframed Mode

Table 21: Feature History

Feature Name	Release Information	Description
Unframed Framing Support on an E1 and Channel STM links	Cisco IOS XE Bengaluru 17.5.1	In this release, a new framing mode unframed is supported for the 1 port OC-48/STM-16 or 4 port OC-12/OC-3 / STM-1/STM-4 + 12 port T1/E1 + 4 port T3/E3 CEM Interface Module. With the unframed mode, you can create serial interfaces under the electrical E1 mode.

Starting with Cisco IOS XE 17.5.1, you can create a channel group in the unframed mode only on the E1 interface.

To create channel group in the unframed mode, use the following commands:

```
router(config)#controller e1 0/2/0
```

```
router(config-controller)#framing unframed
router(config-controller)#channel-group channel-grp-no unframed
```

The following example explains a channel group of number 10 configured on the unframed mode of E1 interface. The default encapsulation of HDLC is used.

```
router(config)#controller e1 0/2/0
router(config-controller)#framing unframed
router(config-controller)#channel-group 10 unframed
```

Creating Serial Interfaces on SDH

Configuring Mode to SDH

To enter into SDH mode, use the following commands:

```
router(config)#controller mediatype 0/bay/port
router(config-controller)#mode sdh
router(config-controller)#exit
```

Creating SDH T3 Interface

To create an SDH T3 interface, use the following commands:

```
router(config)#controller sdh 0/bay/port
router(config-controller)#rate {stm1 | stm4 | stm16}
router(config-controller)#aug mapping au-4
router(config-controller)#au-4 1
router(config-ctrlr-au4)#mode tug-3
router(config-ctrlr-au4)#tug-3 1
router(config-ctrlr-tug3)#[no]mode t3
router(config-ctrlr-tug3)#[no]t3 channel-group 0
router(config-ctrlr-tug3)#exit
```

Creating SDH E3 Interface

To create an SDH E3 interface, use the following commands:

```
router(config)#controller sdh 0/bay/port
router(config-controller)#rate {stm1 | stm4 | stm16}
router(config-controller)#aug mapping au-4
router(config-controller)#au-4 1
router(config-ctrlr-au4)#mode tug-3
router(config-ctrlr-au4)#tug-3 1
router(config-ctrlr-tug3)#[no]mode e3
router(config-ctrlr-tug3)#[no]e3  channel-group 0
router(config-ctrlr-tug3)#exit
```

Creating SDH VC11 Interface

To create an SDH VC11 interface, use the following commands:

```
router(config)#controller sdh 0/bay/port
router(config-controller)#rate {stm1 | stm4 | stm16}
router(config-controller)#aug mapping au-4
router(config-controller)#au-4 1
router(config-ctrlr-au4)#[no]mode tug-3
```

```
router(config-ctrlr-au4)#tug-3 1
router(config-ctrlr-tug3)#[no]mode vc1x
router(config-ctrlr-tug3)#tug-2 1 payload vc11
router(config-ctrlr-tug2-vcx)#[no]t1 1  channel-group 0 timeslots 1-24
router(config-ctrlr-tug3)#exit
```

Creating SDH VC12 Interface

To create an SDH VC12 interface, use the following commands:

```
router(config)#controller sdh 0/bay/port
router(config-controller)#rate {stm1 | stm4 | stm16}
router(config-controller)#aug mapping au-4
router(config-controller)#au-4 1
router(config-ctrlr-au4)#[no]mode tug-3
router(config-ctrlr-au4)#tug-3 1
router(config-ctrlr-tug3)#[no]mode vc1x
router(config-ctrlr-tug3)#tug-2 1 payload vc12
router(config-ctrlr-tug2-vcx)#[no]e1 1  channel-group 0 timeslots 1-31
router(config-ctrlr-tug3)#exit
```

Creating SDH VC4-nc Interface

To create an SDH VC4-nc concatenated interface, use the following commands:

```
router(config)#controller sdh 0/bay/port
router(config-controller)#rate {stm1 | stm4 | stm16}
router(config-controller)#aug mapping au-4
router(config-controller)#au-4 1
router(config-ctrlr-au4)#[no]mode vc4
router(config-ctrlr-au4)#[no]channel-group 0
router(config-ctrlr-tug3)#exit
```

Creating SDH T3 Interface with AUG-3 Mapping

To create an SDH T3 interface with AUG-3 AUG mapping, use the following commands:

```
router(config)#controller sdh 0/bay/port
router(config-controller)#aug mapping au-3
router(config-controller)#au-3 1
router(config-ctrlr-au3)#[no]mode t3
router(config-ctrlr-au3)#[no]t3 channel-group 0
router(config-ctrlr-au3)#exit
```

Creating SDH VC11 Interface with AUG-3 Mapping

To create an SDH VC11 interface with AUG-3 AUG mapping, use the following commands:

```
router(config)#controller sdh 0/bay/port
router(config-controller)#au-3 1
router(config-ctrlr-au3)#[no]mode vc1x
router(config-ctrlr-au3)#tug-2 1 payload vc11
router(config-ctrlr-tug2-vcx)#[no] t1 1 channel-group 0 timeslots 1-24
router(config-ctrlr-tug3)#exit
```

Creating SDH VC12 Interface with AUG-3 Mapping

To create an SDH VC12 interface with AUG-3 AUG mapping, use the following commands:

```
router(config)#controller sdh 0/bay/port
router(config-controller)#au-3 1
```

```
router(config-ctrlr-au3)#[no]mode vc1x
router(config-ctrlr-au3)#tug-2 1 payload vc12
router(config-ctrlr-tug2-vcx)#[no]e1 1 channel-group 0 timeslots 1-31
router(config-ctrlr-tug3)#exit
```

The following example explains SDH serial interface is configured with rate STM1 with AU-4 mapping and TUG-3 and T3 mode:

```
router(config)#controller sdh 0/3/4
router(config-controller)#rate stm1
router(config-controller)#aug mapping au-4
router(config-controller)#au-4 1
router(config-ctrlr-au4)#mode tug-3
router(config-ctrlr-au4)#tug-3 1
router(config-ctrlr-tug3)#mode t3
router(config-ctrlr-tug3)#t3  channel-group 0
router(config-ctrlr-tug3)#exit
```

Creating Serial Interfaces on SONET

Setting Controller Mode to SONET

To enter into SONET mode, use the following commands:

```
router(config)#controller mediatype 0/bay/port
router(config-controller)#mode sonet
router(config-controller)#exit
```

Creating T3 Serial Interface

To create a channel group on the T3 interface, use the following commands:

```
router(config)#controller sonet 0/bay/port
router(config-controller)#rate {oc3 | oc12 | oc48}
router(config-controller)#sts-1  1
router(config-controller)#[no]mode t3
router(config-controller)#[no]t3 channel-group 0
router(config-controller)#exit
```

Creating VT1.5 Serial Interface

To create a channel group on the VT1.5 interface, use the following commands:

```
router(config)#controller sonet 0/bay/port
router(config-controller)#rate oc3
router(config-controller)#sts-1  1
router(config-controller)#[no]mode vt-15
router(config-controller)#[no]vtg 1 t1 1 channel-group 0 timeslots  1-24
router(config-controller)#exit
```

Creating CT3 Serial Interface

To create a channel group on the CT3 interface, use the following commands:

```
router(config)#controller sonet 0/bay/port
router(config-controller)#rate oc3
router(config-controller)#sts-1  1
```

```
router(config-controller)#[no]mode ct3
router(config-controller)#[no]t1  1 channel-group 0  timeslots 1-24
router(config-controller)#exit
```

Note While specifying time slot, ensure that you specify the complete time slot.

Creating Concatenated Mode Serial Interface

To create a channel group on the concatenated mode serial interface, use the following commands:

```
router(config)#controller sonet 0/bay/port
router(config-controller)#rate oc3
router(config-controller)#sts-1  1 - 3 mode sts-3c
router(config-controller)#channel-group 0
router(config-controller)#exit
```

The following example explains SONET interface that is configured with OC-3 rate, STS-1 as 1, and mode as T3.The serial interface is modified for PPP encapsulation.

```
router(config)#controller sonet 0/3/4
router(config-controller)#rate oc3
router(config-controller)#sts-1  1
router(config-controller)#mode t3
router(config-controller)#t3  channel-group 0
router(config-controller)#end
router(config)#interface serial 0/3/4 .1
router(config-if)#no ip address
router(config-if)# encapsulation ppp
```

Modifying Encapsulation to PPP

By default, HDLC is used for encapsulation. You can modify encapsulation to PPP on a serial interface using the **encapsulation ppp** command.

The ***channel-id*** varies based on the mode set and the circuit type. For more information, see the Serial Interface Supported Modes section.

To modify encapsulation on the serial interface, use the following commands:

```
router(config)#interface serial 0/bay/port.channel-id
router(config-if)#no ip address
router(config-if)# encapsulation ppp
```

IPv4 or IPv6 Interworking Multiservice Gateway Pseudowire over HDLC or PPP

L2VPN Interworking Multiservice Gateway

Table 22: Feature History

Feature Name	Release Information	Feature Description
CEM and IP IW Feature Parity for A900-IMA1Z8S-CXMS and A900-IMA3G-IMSG Interface Modules	Cisco IOS XE Bengaluru 17.4.1	Support for NxDS0 iMSG IPv4 and NxDS0 APS iMSG IPv4 on A900-IMA1Z8S-CXMS and A900-IMA3G-IMSG Interface Module.

Layer 2 transport over MPLS and IP already exists for like-to-like attachment circuits, such as Ethernet-to-Ethernet or PPP-to-PPP. Layer 2 Virtual Private Network (L2VPN) Interworking Multiservice Gateway (iMSG) builds on this functionality by allowing disparate attachment circuits to be connected. An iMSG function facilitates the translation between the different Layer 2 encapsulations.

L2VPN iMSG Mode

L2VPN iMSG works in IP (routed) mode that facilitates transport of IPv4 or IPv6 payload in HDLC or PPP frames to Ethernet, over an MPLS network. The configuration is supported on both A900-RSP2A-128 and A900-RSP3C-400-S . You specify the mode by issuing the **`interworking ip`** command in pseudowire-class configuration mode.

Starting with Cisco IOS XE 17.1.x release, the IPv6 iMSG is supported.

The **`interworking`** command causes the attachment circuits to be terminated locally. The **ip** keyword causes IP packets to be extracted from the attachment circuit and sent over the pseudowire. Packets with IPv4 or IPv6 payload only are transported over pseudowire.

IP Interworking Mode

The CE routers encapsulate the IP on the link between the CE router and PE router. A new VC type is used to signal the IP pseudowire in MPLS. Translation between the L2 and IP encapsulations across the pseudowire is required. Special consideration is given to the address resolution and routing protocol operation, because these operations are handled differently on different L2 encapsulations.

In routed iMSG, IP packets that are extracted from the ACs are sent over the pseudowire. The pseudowire works in the IP Layer 2 transport (VC type 0x000B) like-to-like mode. The iMSG function at the network service provider's (NSP) end performs the required adaptation that is based on the AC technology. Non-IPv4 or non-IPv6 packets are not forwarded on pseudowire. Only packets with the IPv4 or IPv6 payload are transported over the pseudowire.

The following table details on the packets that are terminated locally:

Table 23: List of Packets Locally Terminated

Protocol	Packets (Locally Terminated)	PID Number
Cisco HDLC	SLARP, LCP, or RARP	0x8035
Cisco HDLC	NCP or ARP	0x0806
PPP	LCP	0xCxxx to 0xFxxx
PPP	NCP	0x8xxx to 0xBxxx

HDLC or PPP to Ethernet IPv4 or IPv6 iMSG Pseudowire

Starting with Cisco IOS XE 16.9.1 release, the L2VPN iMSG allows you to connect disparate attachment circuits, for example, TDM and Ethernet attachment circuits.

For pseudowires operated in the IP (routed) mode, the IP packets are extracted from the attachment circuit and sent over the pseudowire.

Once IPv4 or IPv6 iMSG is configured, create a serial interface with specific channel identifier.

When a serial interface is UP, an internal label is allocated and LDP negotiation with a peer is performed for a remote label. A pseudowire is created and bound to HDLC or PPP channel. Based on the pseudowire configuration, you can permit IPv4 payload traffic with an allocated internal MPLS label.

The default encapsulation for all serial interfaces is HDLC. You can change the encapsulation to PPP. You can cross connect the attachment circuit segment with specific VC identifier and the pseudowire segment.

IPv4 or IPv6 iMSG Pseudowire Supported Modes

IPv4 or IPv6 iMSG pseudowire is supported on the following modes:

- T1 or E1
- T3 or E3
- Channelized T3 or E3 (channelized to T1 or E1)
- SDH
- SONET

Limitations of IPv4 or IPv6 iMSG Pseudowire on HDLC or PPP Serial Interfaces

The following limitations apply to IPv4 or IPv6 iMSG pseudowire on HDLC or PPP serial interfaces:

- IPv4 or IPv6 iMSG pseudowire with HDLC or PPP attachment circuit is supported only on the A900-IMA3G-IMSG variant for A900-RSP2A-128 and A900-RSP3C-400-S.
- L3 termination, bridging, and local switching on SERIAL-ACR interfaces (IPv4 and IPv6) are not supported, only L3 termination is supported on IPv4 serial interfaces.
- IPv4 or IPv6 over HDLC or PPP is not supported on Nx DS0 serial interfaces.
- T1 framing SF is not supported.

- Serial-ACR HDLC or PPP is not supported for STS-12C or VC4-4C and STS-48C or VC4-16C modes.
- HDLC or PPP is not supported for CE3 modes.
- Modifying MTU value is not supported for IPv6 iMSG pseudowire.
- Scrambling is not supported in the POS mode.
- IPv6 is not supported on RSP2 modules for Layer 3 termination on HDLC or PPP serial interfaces.

iMSG Restrictions for ASR 900 1-Port OC-192 or 8-Port Low Rate CEM 20G Bandwidth Interface Module (A900-IMA1Z8S-CXMS)

iMSG Restrictions - Cisco IOS XE Amsterdam 17.3.1 release

- MLPPP is not supported for iMSG.
- MLPPP ACR is not supported.
- nxDS0 iMSG is not supported until Cisco IOS XE Amsterdam 17.3.1.

  Starting with Cisco IOS XE Bengaluru 17.4.1, nxDS0 iMSG IPv4 is supported and.iMSG IPv6 is not supported.
- UPSR-only SONET modes such as VT1.5, STS-3C, STS-12C, and STS-48C are supported.

Bandwidth Restrictions - Cisco IOS XE Amsterdam 17.3.1 release

- Supports 2.5 G for iMSG
- iMSG supports upto STS-48c for concatenation

How to Configure IPv4 or IPv6 iMSG Pseudowire on HDLC or PPP Interface

This section provides the following information about configuring an IPv4 or IPv6 iMSG pseudowire on an HLDC or PPP interface:

- Configuring L2VPN iMSG, on page 160
- Configuring Cross-Connect Under Attachment Circuit, on page 161

Configuring L2VPN iMSG

To configure L2VPN iMSG, create a pseudowire class with the tunneling encapsulation as MPLS. The **interworking** command specifies the type of payload traffic that flows across the pseudowire tunnel. Configure pseudowire class only once on a device.

You can also configure **control-word** as an optional command.

To configure L2VPN IPv4 iMSG, use the following commands:

```
router>enable
router#configure terminal
router(config)#pseudowire-class pw-class-name
router(config-pw)#encapsulation mpls
router(config-pw)# interworking ip
```

```
router(config-pw)# control-word
```

To configure L2VPN IPv6 iMSG, use the following commands:

```
router>enable
router#configure terminal
router(config)#interface pseudowire pw-number
router(config-if)# encapsulation mpls
router(config-if)# neighbor <peer-address><vcid-value>
router(config-xconnect)# control-word include
```



Note Based on the far-end router, the control-word needs to be enabled or disabled.

The following example shows how to configure L2VPN IPv6 iMSG:

```
interface pseudowire30
 encapsulation mpls
 neighbor 10.2.2.2 30
 control-word include
```

Configuring Cross-Connect Under Attachment Circuit

The **xconnect** command binds the attachment circuit to an L2VPN pseudowire for cross connect service. The virtual circuit identifier creates the binding between a pseudowire that is configured on a PE router and an attachment circuit in a CE device.

To perform IPv4 cross connection between an AToM routed pseudowire and attachment circuit, use the following commands:

```
router(config)#interface serial 0/bay/port.channel-id
router(config-if)#xconnect ip-address vc-id pw-class atom-iw-routed
```

To perform IPv6 cross connection between pseudowire and attachment circuit, use the following commands:

```
router(config)#l2vpn xconnect context xconnect-name
router(config-xconnect)#interworking ipv6
router(config-xconnect)#member pseudowire pw-number
router(config-xconnect)#member serial 0/bay/port.channel-id
```

Verifying IPv4 or IPv6 iMSG Pseudowire over HDLC or PPP Configuration

The following **show interface serial** *0/bay/port.vc-number* command displays information about encapsulation and statistics of a serial interface.

To display configuration information on the serial interface, use the **show interface serial** command:

```
Router# show interface serial 0/5/19.8
 Serial0/5/19.8 is up, line protocol is up
  Hardware is A900RSP2A-128
  MTU 1500 bytes, BW 1536 Kbit/sec, DLY 20000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation PPP, LCP Open
  Stopped: TAGCP
```

```
 Open: IPCP, crc 16, loopback not set
 Keepalive set (10 sec)
 Last input 00:00:04, output 00:00:04, output hang never
 Last clearing of "show interface" counters 23:52:46
 Input queue: 0/375/0/0 (size/max/drops/flushes); Total output drops: 0
 Queueing strategy: fifo
 Output queue: 0/40 (size/max)
 5 minute input rate 0 bits/sec, 0 packets/sec
 5 minute output rate 0 bits/sec, 0 packets/sec
    16201 packets input, 712844 bytes, 0 no buffer
    Received 0 broadcasts (0 IP multicasts)
    0 runts, 0 giants, 0 throttles
    0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
    16205 packets output, 696835 bytes, 0 underruns
    0 output errors, 0 collisions, 1 interface resets
    0 unknown protocol drops
    0 output buffer failures, 0 output buffers swapped out
    1 carrier transitions
PW stats

0 input packets ,0 output packets,
0 input bytes, 0 output bytes, 0 input packet drop
no alarm present
 VC 2: timeslot(s): 1-24, Transmitter delay 0, non-inverted data
```

The **show platform software tdm-combo vc info** command helps you to identify the bay, port, STS path, T1, and channel group associated with a serial interface:

```
router#show platform software tdm-combo vc info
BAY  PORT PATH  T1      CHANNEL          VC         HWIDB
spa in bay:0 is NULL
spa in bay:1 is NULL
5    19   1      1          0        Serial0/5/19.1  1
5    19   1      8          0        Serial0/5/19.8  2
TOTAL ENTRIES :2
```

The **show running-config interface serial 0/5/19.8** command provides information about the current configuration under the serial interface 0/5/19.8:

```
router#show running-config interface serial 0/5/19.8
Building configuration...

Current configuration : 147 bytes
!
interface Serial0/5/19.8
 no ip address
 encapsulation ppp
 ppp authentication chap
 xconnect 192.168.2.6 207 encapsulation mpls pw-class ip-iw
end

BYOS-RSP3#sh xconnect all
Legend:    XC ST=Xconnect State  S1=Segment1 State  S2=Segment2 State
  UP=Up       DN=Down            AD=Admin Down      IA=Inactive
  SB=Standby  HS=Hot Standby     RV=Recovering      NH=No Hardware

XC ST  Segment 1                         S1 Segment 2                          S2
------+---------------------------------+--+---------------------------------+--
UP pri   ac Se0/5/19.8(PPP)              UP mpls 192.168.2.6:207                  UP
```

The **show mpls l2transport vc 207 detail** command provides information on pseudowire corresponding to VC ID 207:

```
Local interface: Se0/5/19.8 up, line protocol up, PPP up
  Interworking type is IP
  Destination address: 192.168.2.6, VC ID: 207, VC status: up
    Output interface: Gi0/3/7, imposed label stack {16}
    Preferred path: not configured
    Default path: active
    Next hop: 209.165.202.129
  Create time: 23:31:56, last status change time: 23:31:54
    Last label FSM state change time: 23:31:56
  Signaling protocol: LDP, peer 192.168.2.6:0 up
    Targeted Hello: 192.168.2.10(LDP Id) -> 192.168.2.6, LDP is UP
    Graceful restart: configured and not enabled
    Non stop routing: not configured and not enabled
    Status TLV support (local/remote)   : enabled/supported
      LDP route watch                   : enabled
      Label/status state machine        : established, LruRru
      Last local dataplane   status rcvd: No fault
      Last BFD dataplane     status rcvd: Not sent
      Last BFD peer monitor  status rcvd: No fault
      Last local AC  circuit status rcvd: No fault
      Last local AC  circuit status sent: No fault
      Last local PW i/f circ status rcvd: No fault
      Last local LDP TLV     status sent: No fault
      Last remote LDP TLV    status rcvd: No fault
      Last remote LDP ADJ    status rcvd: No fault
    MPLS VC labels: local 512, remote 16
    Group ID: local n/a, remote 0
    MTU: local 1500, remote 1500
    Remote interface description:
  Sequencing: receive disabled, send disabled
  Control Word: On
  SSO Descriptor: 192.168.2.6/207, local label: 512
  Dataplane:
    SSM segment/switch IDs: 8219/8218 (used), PWID: 1
  VC statistics:
    transit packet totals: receive 0, send 0
    transit byte totals:   receive 0, send 0
    transit packet drops:  receive 0, seq error 0, send 0
```

IPv4 or IPv6 Interworking Multiservice Gateway Pseudowire over Frame Relay

Frame Relay for iMSG

Table 24: Feature History

Feature Name	Release Information	Description
Frame Relay Support for IP Interworking	Cisco IOS XE Cupertino 17.8.1	Support for frame relay encapsulation on iMSG serial interface for the following interface modules: • 1-port OC-48/STM-16 or 4-port OC-12/OC-3 / STM-1/STM-4 + 12-port T1/E1 + 4-port T3/E3 CEM interface module • ASR 900 1-port OC-192 or 8-port Low Rate CEM 20G bandwidth interface module Frame Relay being a streamlined protocol facilitates higher performance and greater efficiency.

Frame Relay is an industry-standard, switched data link layer protocol that handles multiple virtual circuits using encapsulation between connected devices.

Frame Relay provides a packet-switching data communications capability that is used across the interface between user devices (such as routers, bridges, host machines) and network equipment (such as switching nodes). User devices are often referred to as data terminal equipment (DTE), while network equipment that interfaces to DTE is often referred to as data circuit-terminating equipment (DCE). The network providing the Frame Relay interface can be either a carrier-provided public network or a network of privately owned equipment serving a single enterprise.

As an interface between user and network equipment, Frame Relay provides a means for statistically multiplexing many logical data conversations (referred to as virtual circuits) over a single physical transmission link. This contrasts with systems that use only time-division-multiplexing (TDM) techniques for supporting multiple data streams. Frame Relay's statistical multiplexing provides more flexible and efficient use of available bandwidth. It can be used without TDM techniques or on top of channels that are provided by TDM systems.

Frame relay is supported only on the RSP3 module starting with Cisco IOS XE Cupertino 17.8.x release.

Limitations of IPv4 or IPv6 iMSG Pseudowire on Frame Relay Serial Interfaces

- Subinterfaces with point-to-multipoint are not supported. Only point-to-point subinterfaces are supported.
- From release Cisco IOS XE Cupertino 17.9.1 onwards:
  - QoS on serial interface is supported.
  - On frame relay, subinterface operations (for example, shut and no shut) are not supported on HDLC and PPP serial interfaces.
  - CT3-E1 mode is not supported on HDLC and PPP serial interfaces, and you cannot enable frame relay on these interfaces.
  - Due to limitation from the Cisco series 7600 router side, the IPv6 ping fails with encapsulation as Cisco for frame relay.

    For example, consider the following scenario:

    CE1 (7600 router) FR-Encap Cisco-IPv6 <-> FR-Encap Cisco-IPv6 iMSG PE1

    The CE (7600 router) sending IETF packet (having Cisco encapsulation with the IPv6 address) with the format as 0x038E, then the expected packet format to arrive at PE side is 0x86DD.

    However, the IPv6 ping fails with encapsulation as Cisco for frame relay.
- Subinterface number and data-link connection identifier (DLCI) number should be same for local connect and cross connect.
- DTE interface type for frame relay is not supported.
- Local connect is supported with IETF only, and not with CISCO (default).
- Local connect protection is not supported.
- On frame relay subinterface, any functional and maintenance configurations (for example, shut or no shut, or DLCI) aren't supported.
- The cross connect configuration using the **l2vpn xconnect context xconnect-name** command format isn't supported.

Scale Supported for iMSG Pseudowire on Frame Relay Serial Interfaces

The following table describes the scale information that is applicable for serial interface (includes both main and subinterface):

Table 25: Scale Supported on iMSG Frame Relay Serial Interfaces

Interface Module/System	Scale Supported
Frame Relay Pseudowire supported per Interface Module	1000
Frame Relay Pseudowire supported per System	4000
Number of DLCI supported per interface	25

Interface Module/System	Scale Supported
Number of DLCI supported per Interface Module	1000
Number of DLCI supported per System	4000

How to Configure IPv4 or IPv6 iMSG Pseudowire on Frame Relay Serial Interface

Modifying Encapsulation to Frame Relay

By default, HDLC is used for encapsulation. You can modify encapsulation to frame relay on a serial interface using the **encapsulation frame-relay** command. You can configure the frame relay encapsulation for the interface as Cisco or IETF. The default encapsulation type for frame relay is Cisco. On the frame relay interface, you can configure interface type and Local Management Interface (LMI) type. With interface type, you can set the interface as Data Communications Equipment (DCE). Though the default option displays as Data Transmission Equipment (DTE), the DTE is not supported. The LMI types that are supported are CISCO, ANSI, and q933A, and the default value is Cisco.

The ***channel-id*** varies based on the mode set and the circuit type.

To modify encapsulation on the serial interface to frame relay, use the following commands:

```
router(config)#interface serial 0/bay/port.channel-id
router(config-if)#no ip address
router(config-if)# encapsulation frame-relay (cisco | ietf)
router(config-if)# frame-relay intf-typedce
router(config-if)# frame-relay lmi-type(cisco | ansi | q033a}
router(config-if)# end
```

Configuring Frame Relay

Configuring Frame Relay for T1 or E1 Serial Interface and Configuring Sub-interface for Serial Interface

```
controller T1 0/4/0
 threshold sd-ber 6
 threshold sf-ber 3
 framing esf
 linecode b8zs
 cablelength short 110
 channel-group 0 timeslots 1-24
 no snmp trap link-status

interface Serial0/4/0.1
 no ip address
 encapsulation frame-relay
 frame-relay lmi-type q933a

interface Serial0/4/0.1/21 point-to-point
```

Configuring Frame Relay for T3 or E3 Serial Interface and Configuring Sub-interface for Serial Interface

```
controller T3 0/4/12
 no snmp trap link-status
 threshold sd-ber 6
 threshold sf-ber 3
 no channelized
 framing c-bit
 cablelength short
 channel-group 0

interface Serial0/4/12.1
 no ip address
 encapsulation frame-relay IETF
 frame-relay lmi-type ansi

interface Serial0/4/12.1/25 point-to-point
```

Configuring Frame Relay for OCx Serial Interface and Configuring Sub-interface for Serial Interface

```
controller SONET 0/4/19
 no snmp trap link-status
 rate OC3
 no ais-shut
 alarm-report all
 clock source internal
 !
 sts-1 1
  clock source internal
  mode ct3
  t3 framing c-bit
  t3 clock source internal
  t1 1 channel-group 1 timeslots 1-24
 !
 sts-1 2
  clock source internal
  mode vt-15
  vtg 1 t1 1 channel-group 2 timeslots 1-24
 !
 sts-1 3
  clock source internal
  mode t3
  t3 framing c-bit
  t3 channel-group 0
  t3 clock source internal
interface Serial0/4/19.1
 no ip address
 encapsulation frame-relay
interface Serial0/4/19.1/32 point-to-point
interface Serial0/4/19.29
 no ip address
 encapsulation frame-relay IETF
 frame-relay lmi-type ansi
interface Serial0/4/19.29/33 point-to-point
interface Serial0/4/19.57
 no ip address
 encapsulation frame-relay
 frame-relay lmi-type q933a
interface Serial0/4/19.57/34 point-to-point
```

Configuring Frame Relay for POS Serial Interface and Configuring Sub-interface for Serial Interface

```
controller SONET 0/4/18
 no snmp trap link-status
```

```
 rate OC3
 no ais-shut
 alarm-report all
 clock source internal
 !
 sts-1 1 - 3 mode sts-3c
  clock source internal
  overhead c2 207

  channel-group 0
interface Serial0/4/18.1
 no ip address
 encapsulation frame-relay
 pos report pplm
 pos report ptim
interface Serial0/4/18.1/40 point-to-point
```

Configuring Frame Relay for NxDS0 Serial Interface and Configuring Sub-interface for Serial Interface

```
controller T1 0/4/1
 threshold sd-ber 6
 threshold sf-ber 3
 framing esf
 linecode b8zs
 cablelength short 110
 channel-group 4 timeslots 1-10
 no snmp trap link-status

interface Serial0/4/1.1:4
 no ip address
 encapsulation frame-relay

interface Serial0/4/1.1:4/45 point-to-point
```

Configuring L2VPN iMSG Using Local Connect for Frame Relay

Configuring L2VPN iMSG Using IPv4 Local Connect for Frame Relay

Once you configure frame relay and subinterface for serial interface, you can configure L2VPN iMSG local connect.

```
connect <local-connect-keyword> GigabitEthernet slot/bay/port vc-number Serial
slot/bay/port.channel.id/sub-interface-number dlci-number interworking ip
```

Example

```
connect frsub21vlcv4 GigabitEthernet0/0/3 100 Serial0/2/19.1/21 21 interworking ip
```

Configuring L2VPN iMSG Using IPv6 Local Connect for Frame Relay

```
connect <local-connect-keyword> GigabitEthernet slot/bay/port vc-number Serial
slot/bay/port.channel.id/sub-interface-number dlci-number interworking ipv6
```

Example

```
connect frsub21vlcv6 GigabitEthernet0/0/3 150 Serial0/2/19.8/21 21 interworking ipv6
```

Configuring L2VPN iMSG Using Cross Connect for Frame Relay

Ensure that you create pseudowire class template before proceeding to cross connect step for IPv4 and IPv6 L2VPN.

Create Pseudowire Class Template for IPv4 and IPv6

```
pseudowire-class <pseudowire-class-name>
encapsulation mpls
interworking {ip | ipv6}
control-word
```

Example

Create Pseudowire Class Template for IPv4

```
pseudowire-class serial_test
encapsulation mpls
interworking ip
control-word
```

Create Pseudowire Class Template for IPv6

```
pseudowire-class serial_testipv6
encapsulation mpls
interworking ipv6
control-word
```

Configuring L2VPN iMSG Using IPv4 Cross Connect for Frame Relay

Once you configure frame relay and subinterface for serial interface, you can configure L2VPN iMSG cross connect.

The cross connect configuration using the **l2vpn xconnect context xconnect-name** command format is not supported. Ensure that you use the following command format to perform cross connect configuration:

```
connect <cross-connect-keyword> Serial slot/bay/port.channel.id/sub-interface-number
dlci-number  l2transport
xconnect ipv4-address vc-number encapsulation mpls pw-class pw-name
```

Example

```
connect frsub21ipv4 Serial0/2/19.43/21 21 l2transport
 xconnect 10.2.2.2 400 encapsulation mpls pw-class serial_test
```

Configuring L2VPN iMSG Using IPv6 Cross Connect for Frame Relay

```
connect <local-connect-keyword> Serial slot/bay/port.channel.id/sub-interface-number
dlci-number  l2transport
xconnect ipv4-address vc-number encapsulation mpls pw-class pw-name
```

Example

```
connect frsub21ipv6 Serial0/2/19.50/21 21 l2transport
```

```
 xconnect 10.2.2.2 450 encapsulation mpls pw-class serial_testipv6
```

Verifying IPv4 or IPv6 iMSG Pseudowire over Frame Relay Configuration

Use the following **show** commands to verify the frame relay configuration on iMSG pseudowire:

- **show interface Serial *<slot/bay/port.channel.id>***
- **show ip interface brief | interface *<slot/bay/port.channel.id>***
- **show frame-relay lmi interface Serial *<slot/bay/port.channel.id>***
- **show frame-relay pvc interface Serial *<slot/bay/port.channel.id>***
- **show xconnect all**
- **show platform software tdm-combo vc info**
- **show mpls l2transport vc <vc-id> detail**

```
Router#show ip interface brief | interface 0/4/16.28
Serial0/4/16.28        unassigned      YES unset  up                    up
Serial0/4/16.28/21     unassigned      YES unset  up                    up

Router#show interface Serial0/4/16.28
Serial0/4/16.28 is up, line protocol is up
  Hardware is A900-IMA3G-IMSG
  MTU 1500 bytes, BW 1536 Kbit/sec, DLY 20000 usec,
     reliability 252/255, txload 138/255, rxload 255/255
  Encapsulation FRAME-RELAY IETF, crc 16, loopback not set
  Keepalive set (10 sec)
  LMI enq sent  0, LMI stat recvd 0, LMI upd recvd 0
  LMI enq recvd 25, LMI stat sent  25, LMI upd sent  0, DCE LMI up
  LMI DLCI 0  LMI type is CCITT  frame relay DCE  segmentation inactive
  Broadcast queue 0/64, broadcasts sent/dropped 0/0, interface broadcasts 0
  Last input 00:00:02, output 00:00:02, output hang never
  Last clearing of "show interface" counters 00:04:06
  Input queue: 0/375/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: fifo
  Output queue: 0/40 (size/max)
  5 minute input rate 11661000 bits/sec, 4824731 packets/sec
  5 minute output rate 833000 bits/sec, 554183 packets/sec
     25 packets input, 375 bytes, 0 no buffer
     Received 0 broadcasts (0 IP multicasts)
     0 runts, 0 giants, 0 throttles
     1 input errors, 1 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     25 packets output, 400 bytes, 0 underruns
     Output 0 broadcasts (0 IP multicasts)
     0 output errors, 0 collisions, 0 interface resets
     0 unknown protocol drops
     0 output buffer failures, 0 output buffers swapped out
     0 carrier transitions
  no alarm present
  VC 7: timeslot(s): 1-24, Transmitter delay 0, non-inverted data

Router#show frame-relay lmi interface Serial0/4/16.28

LMI Statistics for interface Serial0/4/16.28 (Frame Relay DCE) LMI TYPE = CCITT
  Invalid Unnumbered info 0  Invalid Prot Disc 0
  Invalid dummy Call Ref 0  Invalid Msg Type 0
```

```
  Invalid Status Message 0  Invalid Lock Shift 0
  Invalid Information ID 0  Invalid Report IE Len 0
  Invalid Report Request 0  Invalid Keep IE Len 0
  Num Status Enq. Rcvd 17  Num Status msgs Sent 17
  Num Update Status Sent 0  Num St Enq. Timeouts 0
```

```
Router#show frame-relay pvc interface Serial0/4/16.28

PVC Statistics for interface Serial0/4/16.28 (Frame Relay DCE)

              Active     Inactive      Deleted       Static
  Local          0            0            0            0
  Switched       1            0            0            0
  Unused         0            0            0            0

DLCI = 21, DLCI USAGE = SWITCHED, PVC STATUS = ACTIVE, INTERFACE = Serial0/4/16.28/21

  input pkts 0             output pkts 0            in bytes 0
  out bytes 0              dropped pkts 0           in pkts dropped 0
  out pkts dropped 0                 out bytes dropped 0
  in FECN pkts 0           in BECN pkts 0           out FECN pkts 0
  out BECN pkts 0          in DE pkts 0             out DE pkts 0
  out bcast pkts 0         out bcast bytes 0
  30 second input rate 0 bits/sec, 0 packets/sec
  30 second output rate 0 bits/sec, 0 packets/sec
  switched pkts 0          FECNs set 0              BECNs set 0
  Detailed packet drop counters:
  no out intf 0            out intf down 0          no out PVC 0
  in PVC down 0            out PVC down 0           pkt too big 0
  shaping Q full 0         pkt above DE 0           policing drop 0
  connected to pseudowire 10.3.3.3 vcid 700, interworking IP
  pvc create time 00:02:03, last time pvc status changed 00:01:45
```

```
Router#show xconnect all
Legend:    XC ST=Xconnect State  S1=Segment1 State  S2=Segment2 State
  UP=Up       DN=Down            AD=Admin Down      IA=Inactive
  SB=Standby  HS=Hot Standby     RV=Recovering      NH=No Hardware

XC ST  Segment 1                         S1 Segment 2                          S2
------+---------------------------------+--+---------------------------------+--
UP pri   ac Se0/4/16.28/21:21(FR DLCI)   UP mpls 10.3.3.3:700                   UP
```

```
Router#show platform software tdm-combo vc info
Media:    Path:                          AUG:   Mode:         Channel:  VC:  Timeslots:
 Serial-Interface:
SONET     SONET 0/4/16.1/7/4             NONE   VT1.5         1         7    1-24
 Serial0/4/16.28
 TOTAL ENTRIES :1
```

```
Router#sh mpls l2transport vc 700 detail
Local interface: Se0/4/16.28/21 up, line protocol up, FR DLCI 21 up
  Interworking type is IP
  Destination address: 10.3.3.3, VC ID: 700, VC status: up
    Output interface: Gi0/3/0, imposed label stack {17}
    Preferred path: not configured
    Default path: active
    Next hop: 209.165.200.225
  Create time: 00:00:45, last status change time: 00:00:44
    Last label FSM state change time: 00:00:45
  Signaling protocol: LDP, peer 10.3.3.3:0 up
    Targeted Hello: 10.2.2.2(LDP Id) -> 10.3.3.3, LDP is UP
```

```
    Graceful restart: configured and not enabled
    Non stop routing: configured and enabled
    Status TLV support (local/remote)   : enabled/supported
      LDP route watch                   : enabled
      Label/status state machine        : established, LruRru
      Last local dataplane   status rcvd: No fault
      Last BFD dataplane     status rcvd: Not sent
      Last BFD peer monitor  status rcvd: No fault
      Last local AC  circuit status rcvd: No fault
      Last local AC  circuit status sent: No fault
      Last local PW i/f circ status rcvd: No fault
      Last local LDP TLV     status sent: No fault
      Last remote LDP TLV    status rcvd: No fault
      Last remote LDP ADJ    status rcvd: No fault
    MPLS VC labels: local 16, remote 17
    Group ID: local 71, remote 9
    MTU: local 1500, remote 1500
    Remote interface description:
  Sequencing: receive disabled, send disabled
  Control Word: On
  SSO Descriptor: 10.3.3.3/700, local label: 16
  Dataplane:
    SSM segment/switch IDs: 4103/4102 (used), PWID: 2
  VC statistics:
    transit packet totals: receive 0, send 0
    transit byte totals:   receive 0, send 0
    transit packet drops:  receive 0, seq error 0, send 0
```

Configuring Frame Relay for APS Protection

Configuring APS on Frame Relay Serial Interface and Configuring Subinterface for Serial Interface

```
controller SONET-ACR 10
 !
 sts-1 1
  mode vt-15
  vtg 1 t1 1 channel-group 1 timeslots 1-24
 !
 sts-1 2

 !
 sts-1 3

interface SERIAL-ACR10.1
 no ip address
 encapsulation frame-relay

interface SERIAL-ACR10.1/21 point-to-point
```

Configuring Frame Relay for UPSR Protection

Configuring UPSR on Frame Relay Serial Interface and Configuring Subinterface for Serial Interface

```
controller protection-group 20
 type vt1.5
 channel-group 20 timeslots 1-24
!

interface Serial-PG20.20
 no ip address
 encapsulation frame-relay
```

```
!
interface Serial-PG20.20/39 point-to-point
```

Configuring Frame Relay L2VPN iMSG for APS Protection

Configuring Frame Relay L2VPN iMSG Using Cross Connect on ACR Interface - APS

```
connect frsubacripv4 SERIAL-ACR10.1/21 21 l2transport
xconnect 10.2.2.2 402 encapsulation mpls pw-class serial_test
```

Configuring Frame Relay L2VPN iMSG for UPSR Protection

Configuring Frame Relay L2VPN iMSG Using Cross Connect on ACR Interface - UPSR

```
connect frsubupsripv4 Serial-PG20.20/39 39 l2transport
xconnect 10.2.2.2 403 encapsulation mpls pw-class serial_test
```

Verifying Frame Relay for APS Protection

```
Router#show ip interface brief | in ACR10
SERIAL-ACR10.1         unassigned      YES unset  up                    down
SERIAL-ACR10.1/21      unassigned      YES unset  down                  down
```

```
Router#show interface SERIAL-ACR10.1
SERIAL-ACR10.1 is up, line protocol is down
  Hardware is N/A
  MTU 1500 bytes, BW 1536 Kbit/sec, DLY 20000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation FRAME-RELAY, crc 16, loopback not set
  Keepalive set (10 sec)
  LMI enq sent  63, LMI stat recvd 0, LMI upd recvd 0, DTE LMI down
  LMI enq recvd 0, LMI stat sent  0, LMI upd sent  0
  LMI DLCI 1023  LMI type is CISCO  frame relay DTE
  Broadcast queue 0/64, broadcasts sent/dropped 0/0, interface broadcasts 0
  Last input never, output 00:00:04, output hang never
  Last clearing of "show interface" counters 00:10:34
  Input queue: 0/375/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: fifo
  Output queue: 0/40 (size/max)
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     0 packets input, 0 bytes, 0 no buffer
     Received 0 broadcasts (0 IP multicasts)
     0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     0 packets output, 0 bytes, 0 underruns
     Output 0 broadcasts (0 IP multicasts)
     0 output errors, 0 collisions, 0 interface resets
     0 unknown protocol drops
     0 output buffer failures, 0 output buffers swapped out
     0 carrier transitions
  alarm present
  VC 1: timeslot(s): 1-24, Transmitter delay 0, non-inverted data
```

```
Router#show frame-relay lmi | beg SERIAL-ACR10.1
LMI Statistics for interface SERIAL-ACR10.1 (Frame Relay DTE) LMI TYPE = CISCO
  Invalid Unnumbered info 0                      Invalid Prot Disc 0
  Invalid dummy Call Ref 0                           Invalid Msg Type 0
```

```
  Invalid Status Message 0                          Invalid Lock Shift 0
  Invalid Information ID 0                            Invalid Report IE Len 0
  Invalid Report Request 0                          Invalid Keep IE Len 0
  Num Status Enq. Sent 75                         Num Status msgs Rcvd 0
  Num Update Status Rcvd 0                      Num Status Timeouts 74
```

```
Router#show platform software tdm-combo vc info  | in ACR
SONET     SONET-ACR 10.1/1/1            NONE   VT1.5         1         2    1-24
 SERIAL-ACR10.1
```

```
Router#show xconnect all | in ACR
DN pri   ac SE-ACR10.1/21:21(FR DLCI)    DN mpls 10.2.2.2:402                  DN
```

```
Router#show mpls l2transport vc 402 detail
Local interface: SE-ACR10.1/21 down, line protocol down, FR DLCI 21 down
  Interworking type is IP
  Destination address: 10.2.2.2, VC ID: 402, VC status: down
    Last error: Local peer access circuit is down
    Output interface: none, imposed label stack {}
    Preferred path: not configured
    Default path: no route
    No adjacency
  Create time: 00:09:32, last status change time: 00:09:32
    Last label FSM state change time: 00:09:32
  Signaling protocol: LDP, peer unknown
    Targeted Hello: 10.1.1.1(LDP Id) -> 10.2.2.2, LDP is DOWN, no binding
    Graceful restart: not configured and not enabled
    Non stop routing: not configured and not enabled
    Status TLV support (local/remote)   : enabled/None (no remote binding
      LDP route watch                   : enabled
      Label/status state machine        : local standby, AC-ready, LndRnd
      Last local dataplane   status rcvd: No fault
      Last BFD dataplane     status rcvd: Not sent
      Last BFD peer monitor  status rcvd: No fault
      Last local AC  circuit status rcvd: DOWN AC(rx/tx faults)
      Last local AC  circuit status sent: DOWN(not-forwarding)
      Last local PW i/f circ status rcvd: No fault
      Last local LDP TLV     status sent: No status
      Last remote LDP TLV    status rcvd: None (no remote binding)
      Last remote LDP ADJ    status rcvd: None (no remote binding)
    MPLS VC labels: local 16, remote unassigned
    Group ID: local 57, remote unknown
    MTU: local 1500, remote unknown
    Remote interface description:
  Sequencing: receive disabled, send disabled
  Control Word: On
  SSO Descriptor: 10.2.2.2/402, local label: 16
  Dataplane:
    SSM segment/switch IDs: 0/0 (used), PWID: 1
  VC statistics:
    transit packet totals: receive 0, send 0
    transit byte totals:   receive 0, send 0
    transit packet drops:  receive 0, seq error 0, send 0
```

Verifying Frame Relay for UPSR Protection

```
Router#show ip interface brief | in PG20
Serial-PG20.20         unassigned      YES unset  down                  down
Serial-PG20.20/39      unassigned      YES unset  down                  down
```

```
Router#show interface Serial-PG20.20
Serial-PG20.20 is down, line protocol is down
  Hardware is NCS4200-3GMS
  MTU 1500 bytes, BW 1536 Kbit/sec, DLY 20000 usec,
     reliability 128/255, txload 1/255, rxload 1/255
  Encapsulation FRAME-RELAY, crc 16, loopback not set
  Keepalive set (10 sec)
  LMI enq sent  0, LMI stat recvd 0, LMI upd recvd 0, DTE LMI down
  LMI enq recvd 0, LMI stat sent  0, LMI upd sent  0
  LMI DLCI 1023  LMI type is CISCO  frame relay DTE
  Broadcast queue 0/64, broadcasts sent/dropped 0/0, interface broadcasts 0
  Last input never, output never, output hang never
  Last clearing of "show interface" counters 00:09:23
  Input queue: 0/375/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: fifo
  Output queue: 0/40 (size/max)
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     0 packets input, 0 bytes, 0 no buffer
     Received 0 broadcasts (0 IP multicasts)
     0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     0 packets output, 0 bytes, 0 underruns
     Output 0 broadcasts (0 IP multicasts)
     0 output errors, 0 collisions, 0 interface resets
     0 unknown protocol drops
     0 output buffer failures, 0 output buffers swapped out
     0 carrier transitions

Router#show frame-relay lmi | beg Serial-PG20.20
LMI Statistics for interface Serial-PG20.20 (Frame Relay DTE) LMI TYPE = CISCO
  Invalid Unnumbered info 0                      Invalid Prot Disc 0
  Invalid dummy Call Ref 0                           Invalid Msg Type 0
  Invalid Status Message 0                           Invalid Lock Shift 0
  Invalid Information ID 0                             Invalid Report IE Len 0
  Invalid Report Request 0                           Invalid Keep IE Len 0
  Num Status Enq. Sent 0                             Num Status msgs Rcvd 0
  Num Update Status Rcvd 0                       Num Status Timeouts 0


Router#show platform software tdm-combo vc info  | in PG
SONET     SONET 0/4/17.1/1/1            NONE   VT1.5         20        3    1-24
 Serial-PG20.20

Router#show xconnect all | in PG
DN pri   ac Se-PG20.20/39:39(FR DLCI)    DN mpls 10.2.2.2:403                 DN

Router#show mpls l2transport vc 403 detail
Local interface: Se-PG20.20/39 down, line protocol down, FR DLCI 39 down
  Interworking type is IP
  Destination address: 10.2.2.2, VC ID: 403, VC status: down
    Last error: Local peer access circuit is down
    Output interface: none, imposed label stack {}
    Preferred path: not configured
    Default path: no route
    No adjacency
  Create time: 00:09:27, last status change time: 00:09:27
    Last label FSM state change time: 00:09:27
  Signaling protocol: LDP, peer unknown
    Targeted Hello: 10.1.1.1(LDP Id) -> 10.2.2.2, LDP is DOWN, no binding
    Graceful restart: not configured and not enabled
```

```
    Non stop routing: not configured and not enabled
    Status TLV support (local/remote)   : enabled/None (no remote binding
      LDP route watch                   : enabled
      Label/status state machine        : local standby, AC-ready, LndRnd
      Last local dataplane   status rcvd: No fault
      Last BFD dataplane     status rcvd: Not sent
      Last BFD peer monitor  status rcvd: No fault
      Last local AC  circuit status rcvd: DOWN AC(rx/tx faults)
      Last local AC  circuit status sent: DOWN(not-forwarding)
      Last local PW i/f circ status rcvd: No fault
      Last local LDP TLV     status sent: No status
      Last remote LDP TLV    status rcvd: None (no remote binding)
      Last remote LDP ADJ    status rcvd: None (no remote binding)
    MPLS VC labels: local 17, remote unassigned
    Group ID: local 62, remote unknown
    MTU: local 1500, remote unknown
    Remote interface description:
  Sequencing: receive disabled, send disabled
  Control Word: On
  SSO Descriptor: 10.2.2.2/403, local label: 17
  Dataplane:
    SSM segment/switch IDs: 0/0 (used), PWID: 2
  VC statistics:
    transit packet totals: receive 0, send 0
    transit byte totals:   receive 0, send 0
    transit packet drops:  receive 0, seq error 0, send 0
```

Scenario 1–Configure L2VPN iMSG Using Local Connect for Frame Relay

Consider a cross connect scenario with the following frame relay configurations on serial interface Serial0/4/16.28:

- Frame relay encapsulation type is set to IETF
- Frame relay LMI type is set to ANSI

Configure T3 Interface

```
controller T3 0/4/12
 no snmp trap link-status
 threshold sd-ber 6
 threshold sf-ber 3
 no channelized
 framing c-bit
 cablelength short
 channel-group 0
```

Configure Serial Interface for Frame Relay and Create Sub Interface

```
interface Serial0/4/12.1
 no ip address
 encapsulation frame-relay IETF
 frame-relay lmi-type ansi
interface Serial0/4/12.1/25 point-to-point
```

Configure L2VPN iMSG Using Local Connect for Frame Relay

```
connect frsub21vlcv4 GigabitEthernet0/0/3 100 Serial0/4/12.1/25 21 interworking ip
```

Verify Frame Relay Configuration on iMSG Pseudowire

```
Router#show interface Serial0/4/12.1
Serial0/4/12.1 is up, line protocol is up
  Hardware is A900-IMA3G-IMSG
  MTU 1500 bytes, BW 1536 Kbit/sec, DLY 20000 usec,
     reliability 252/255, txload 138/255, rxload 255/255
  Encapsulation FRAME-RELAY IETF, crc 16, loopback not set
  Keepalive set (10 sec)
  LMI enq sent  0, LMI stat recvd 0, LMI upd recvd 0
  LMI enq recvd 25, LMI stat sent  25, LMI upd sent  0, DCE LMI up
  LMI DLCI 0  LMI type is CCITT  frame relay DCE  segmentation inactive
  Broadcast queue 0/64, broadcasts sent/dropped 0/0, interface broadcasts 0
  Last input 00:00:02, output 00:00:02, output hang never
  Last clearing of "show interface" counters 00:04:06
  Input queue: 0/375/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: fifo
  Output queue: 0/40 (size/max)
  5 minute input rate 11661000 bits/sec, 4824731 packets/sec
  5 minute output rate 833000 bits/sec, 554183 packets/sec
     25 packets input, 375 bytes, 0 no buffer
     Received 0 broadcasts (0 IP multicasts)
     0 runts, 0 giants, 0 throttles
     1 input errors, 1 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     25 packets output, 400 bytes, 0 underruns
     Output 0 broadcasts (0 IP multicasts)
     0 output errors, 0 collisions, 0 interface resets
     0 unknown protocol drops
     0 output buffer failures, 0 output buffers swapped out
     0 carrier transitions
  no alarm present
  VC 7: timeslot(s): 1-24, Transmitter delay 0, non-inverted data
```

Scenario 2–Configure L2VPN iMSG Using Cross Connect for Frame Relay

Consider a cross connect scenario with the following frame relay configurations on serial interface Serial0/4/16.28:

- Frame relay encapsulation type is set to IETF
- Frame relay LMI type is set to q933a
- Frame relay interface type is set to DCE

Configure T1 Interface

```
controller T1 0/4/16
 threshold sd-ber 6
 threshold sf-ber 3
 framing esf
 linecode b8zs
 cablelength short 110
 channel-group 0 timeslots 1-24
 no snmp trap link-status
```

Configure Serial Interface for Frame Relay and Create Sub Interface

```
interface Serial0/4/16.28
 no ip address
 encapsulation frame-relay IETF
```

```
 ipv6 enable
 frame-relay lmi-type q933a
 frame-relay intf-type dce
interface Serial0/4/16.28/21 point-to-point
```

Create Pseudowire Class Template for IPv6

```
pseudowire-class serial_testipv6
encapsulation mpls
interworking ipv6
control-word
```

Configure L2VPN iMSG Using Cross Connect for Frame Relay

```
connect test Serial0/4/16.28/21 21 l2transport
 xconnect 10.3.3.3 700 encapsulation mpls pw-class serial_testipv6
```

Verify Frame Relay Configuration on iMSG Pseudowire

```
Router#show interface Serial0/4/16.28
Serial0/4/16.28 is up, line protocol is up
  Hardware is A900-IMA3G-IMSG
  MTU 1500 bytes, BW 1536 Kbit/sec, DLY 20000 usec,
     reliability 252/255, txload 138/255, rxload 255/255
  Encapsulation FRAME-RELAY IETF, crc 16, loopback not set
  Keepalive set (10 sec)
  LMI enq sent  0, LMI stat recvd 0, LMI upd recvd 0
  LMI enq recvd 25, LMI stat sent  25, LMI upd sent  0, DCE LMI up
  LMI DLCI 0  LMI type is CCITT  frame relay DCE  segmentation inactive
  Broadcast queue 0/64, broadcasts sent/dropped 0/0, interface broadcasts 0
  Last input 00:00:02, output 00:00:02, output hang never
  Last clearing of "show interface" counters 00:04:06
  Input queue: 0/375/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: fifo
  Output queue: 0/40 (size/max)
  5 minute input rate 11661000 bits/sec, 4824731 packets/sec
  5 minute output rate 833000 bits/sec, 554183 packets/sec
     25 packets input, 375 bytes, 0 no buffer
     Received 0 broadcasts (0 IP multicasts)
     0 runts, 0 giants, 0 throttles
     1 input errors, 1 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     25 packets output, 400 bytes, 0 underruns
     Output 0 broadcasts (0 IP multicasts)
     0 output errors, 0 collisions, 0 interface resets
     0 unknown protocol drops
     0 output buffer failures, 0 output buffers swapped out
     0 carrier transitions
  no alarm present
  VC 7: timeslot(s): 1-24, Transmitter delay 0, non-inverted data


Router#show frame-relay lmi interface Serial0/4/16.28

LMI Statistics for interface Serial0/4/16.28 (Frame Relay DCE) LMI TYPE = CCITT
  Invalid Unnumbered info 0  Invalid Prot Disc 0
  Invalid dummy Call Ref 0  Invalid Msg Type 0
  Invalid Status Message 0  Invalid Lock Shift 0
  Invalid Information ID 0  Invalid Report IE Len 0
  Invalid Report Request 0  Invalid Keep IE Len 0
  Num Status Enq. Rcvd 17  Num Status msgs Sent 17
  Num Update Status Sent 0  Num St Enq. Timeouts 0
```

```
Router#show xconnect all
Legend:    XC ST=Xconnect State  S1=Segment1 State  S2=Segment2 State
  UP=Up       DN=Down            AD=Admin Down      IA=Inactive
  SB=Standby  HS=Hot Standby     RV=Recovering      NH=No Hardware

XC ST  Segment 1                         S1 Segment 2                          S2
------+---------------------------------+--+---------------------------------+--
UP pri   ac Se0/4/16.28/21:21(FR DLCI)   UP mpls 10.3.3.3:700                   UP
```

IPv4 Layer 3 Termination on HDLC or PPP Serial Interfaces

IPv4 Layer 3 Termination on HDLC or PPP Serial Interfaces

Starting with Cisco IOS XE 16.11.x release, you can perform IPv4 Layer 3 termination on HDLC or PPP serial interfaces for RSP3 module on the Cisco ASR 900 Series 4-Port OC3/STM-1 or 1-Port OC12/STM-4 Module (A900-IMA3G-IMSG).

IPv4 routing can be performed using standard routing protocols such as OSPF, BGP, IS-IS, EIGRP, and RIP.

A maximum of 1020 serial interfaces are supported on the Cisco RSP3 module.

This feature supports MPLS IP.

Restrictions for IPv4 Layer 3 Termination on HDLC or PPP Serial Interfaces

- Multicast and QoS features are not supported.
- Frame-relay is not supported.
- BFD is not supported on serial interfaces.
- IPv6 is not supported for layer 3 termination.

How to Configure IPv4 Layer 3 Termination on HDLC or PPP Serial Interfaces

Configuring Protocols

Configuring Routing Protocol

You should configure routing protocols such as OSPF, BGP, IS-IS, EIGRP, and RIP.

For more information on configuring IP Routing protocols, refer the respective Guides:

https://www.cisco.com/c/en/us/support/ios-nx-os-software/ios-xe-3s/products-installation-and-configuration-guides-list.html

Configuring Layer 3 VPN

To configure Layer 3 VPN, refer the MPLS Virtual Private Networks chapter in the MPLS: Layer 3 VPNs Configuration Guide.

Configuring VRF

Before configuring IPv4 Layer 3 flow on a serial interface, ensure that you have configured VRF forwarding. For more information, refer Configuring VFR.

VRF-lite is a feature that enables a service provider to support two or more VPNs, where IP addresses can be overlapped among the VPNs. VRF-lite uses input interfaces to distinguish routes for different VPNs and forms virtual packet-forwarding tables by associating one or more Layer 3 interfaces with each VRF.

With the VRF-lite feature, the router supports multiple VPN routing or forwarding instances in customer edge devices. VRF-lite allows a service provider to support two or more VPNs with overlapping IP addresses using one interface.

To configure VRF, enter the following commands:

```
router#configure terminal
router(config)#vrf definition vrf_test
router(config-vrf)#rd 1:1
router(config-vrf)#address-family ipv4
```

Once VRF is configured, ensure that you specify the Layer 3 interface to be associated with the VRF and then associate the VRF with the Layer 3 interface using the **vrf forwarding vrf-name** command. The interface can be a routed port or SVI.

To configure VRF forwarding, enter the following commands:

```
router#configure terminal
router (config-vrf)# interface interface-id
router (config-if)#vrf forwarding vrf-name
```

Configuring IPv4 Unicast Layer 3 Termination on HDLC or PPP Interfaces

You can enable or disable IPv4 Layer 3 flow on HDLC or PPP serial interfaces. You can use the **vrf forwarding <vrf name>** command optionally on the serial interface.

You can also modify the default MTU 1500 bytes optionallyusing the **mtu** command.

To enable IPv4 Layer 3 flow on a serial interface, enter the following commands:

```
router(config)#interface serial x/y/z.channel-id
router(config-if)#vrf forwarding <vrf name> (optional)
router(config-if)#ip address <ipv4 address> <mask>/<ip address>
router(config-if)#mtu <bytes>
```

To disable IPv4 Layer 3 flow on a serial interface, enter the no form of the command:

```
router(config)#interface serial x/y/z.channel-id
router(config-if)#vrf forwarding <vrf name>
router(config-if)#no ip address <ipv4 address> <mask>/<ip address>
```

```
router(config)#interface serial x/y/z.channel-id
router(config-if)#no vrf forwarding <vrf name>
```

Verifying IPv4 Layer 3 Termination on HDLC or PPP

The following **show interface serial** *0/bay/port.vc-number* command displays information about PPP encapsulation and statistics of a serial interface.

To display configuration information on the serial interface, use the **show interface serial** command:

```
Router# show interface serial 0/5/16.1
 Serial0/5/16.1 is up, line protocol is up
  Hardware is A900RSP2A-128
  Internet address is 172.16.0.1/24
  MTU 1500 bytes, BW 44210 Kbit/sec, DLY 20000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation HDLC, crc 16, loopback not set
  Keepalive set (10 sec)
  Last input 00:00:03, output 00:00:02, output hang never
  Last clearing of "show interface" counters never
  Input queue: 0/375/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: fifo
  Output queue: 0/40 (size/max)
  5 minute input rate 76000 bits/sec, 298 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     99332 packets input, 983489 bytes, 0 no buffer
     Received 0 broadcasts (0 IP multicasts)
     0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     62 packets output, 4832 bytes, 0 underruns
     0 output errors, 0 collisions, 3 interface resets
     0 unknown protocol drops
     0 output buffer failures, 0 output buffers swapped out
     0 carrier transitions
  no alarm present
  DSU mode 0, bandwidth 0 Kbit, scramble 0, VC 3, non-inverted data
```

QoS Support on Serial Interfaces

Table 26: Feature History

Feature Name	Release Information	Description
QoS Support on Serial Interfaces	Cisco IOS XE Cupertino 17.9.1	QoS is supported on serial interfaces. You can apply service policies on egress of L3 terminated serial interfaces with both HDLC and PPP encapsulation. By implementing QoS policies on serial interfaces you can shape, classify, or prioritize the data.

Starting with Cisco IOS XE Cupertino 17.9.1 release, you can apply QoS policy on Layer 3 terminated serial interfaces on HDLC and PPP serial interfaces for RSP3 module on the following interface modules:

- 1-port OC481/ STM-16 or 4-port OC-12/OC-3 / STM-1/STM-4 + 12-Port T1/E1 + 4-Port T3/E3 CEM (A900-IMA3G-IMSG)

- ASR 900 1-port OC-192 or 8-port low rate CEM 20G bandwidth (A900-IMA1Z8S-CXMS)

QoS support on serial interfaces offers the following:

- Egress classification—Classifies packets with qos-group
- Egress shaping—Classifies bandwidth rate
- Egress CBWFQ—Actions bandwidth, BRR or BRP, and shape
- Egress LLQ—Two-level priority and shaping
- Egress WRED—Discard-class-based
- Queue limit—In bytes and micro seconds

Creating QoS Classification

The following examples explain the QoS support on serial interfaces.

Configuring QoS class-map

QoS is supported based on precedence field of the IP header, hence 0–7 qos-groups.

```
class-map match-any qos-group0
 match qos-group 0
class-map match-any qos-group1
 match qos-group 1
class-map match-any qos-group2
 match qos-group 2
class-map match-any qos-group3
 match qos-group 3
class-map match-any qos-group4
 match qos-group 4
class-map match-any qos-group5
 match qos-group 5
class-map match-any qos-group6
 match qos-group 6
class-map match-any qos-group7
 match qos-group 7
```

Configuring QoS policy-map

```
policy-map l3egressqos-groupbrp
 class qos-group0
 class qos-group1
 class qos-group2
 class qos-group3
 class qos-group4
 class qos-group5
 class qos-group6
 class qos-group7
```

Configuring L3 Egress QoS Group

```
router(config)#interface Serial0/7/19.1
router(config-if)#service-policy output l3egressqos-groupbrp
router(config-if)#end
```

Enabling the SDM template

```
router(config)# sdm prefer enable_egr_l3vpn_cm
```

Starting with Cisco IOS XE 17.14.1 release, you must enable the **egr_l3vpn_cm** template before attaching a policy map to an interface.

For the SDM template to take effect, restart the router.

Configuring Shaping

```
policy-map l3egressqos-groupbrp
class qos-group0
             shape average 384000
class qos-group1
             shape average 384000
class qos-group2
             shape average 384000
```

Configuring Bandwidth

```
policy-map l3egressqos-groupbrp
class qos-group0
             bandwidth percent 10
class qos-group1
             bandwidth percent 10
class qos-group2
 bandwidth percent 20
```

Configuring BRP

```
policy-map l3egressqos-groupbrp
class qos-group0
             bandwidth remaining percent 10
class qos-group1
             bandwidth remaining percent 20
class qos-group2
             bandwidth remaining percent 30
```

Configuring BRR

```
policy-map l3egressqos-groupbrp
class qos-group0
             bandwidth remaining ratio 10
class qos-group1
             bandwidth remaining ratio 20
class qos-group2
 bandwidth remaining ratio 30
```

Configuring Priority

```
policy-map l3egressqos-groupbrp
class qos-group0
             priority

/* Priority Percent */
policy-map l3egressqos-groupbrp
class qos-group0
             priority percent 40
```

Configuring WRED

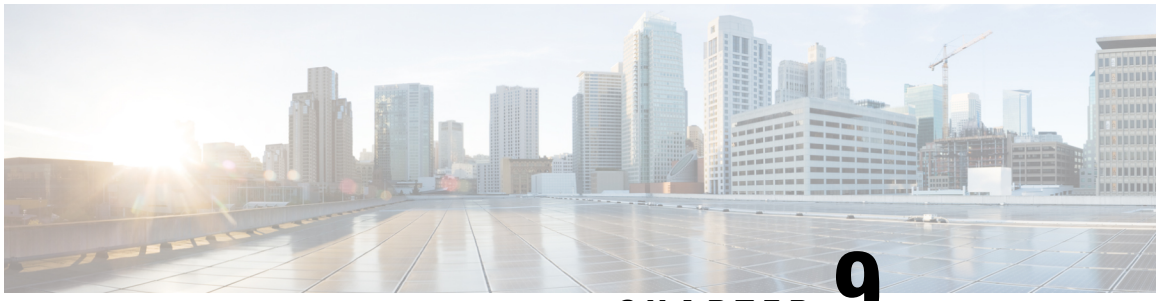
```
class-map match-all qos1
 match qos-group 1

policy-map egress
  class qos1
  shape average 100000000
  queue-limit 300 us
  random-detect discard-class-based
```

```
random-detect discard-class 0 100 us 200 us 100
random-detect discard-class 1 200 us 300 us 100
```

Limitation

- On serial interfaces, for Bandwidth Remaining Percent or Ratio (BRP/BRR):
  - Mixed bandwidth types aren't supported. Always configure the bandwidth command in kbps, percent, remaining percent or remaining ratio but not in mixed.
  - Priority isn't allowed with the bandwidth.
  - When the parent bandwidth is between 384 kbps to 391 kbps: You must reserve a minimum of 15% bandwidth for class-default on T1 interface.
  - When the parent bandwidth is greater than 391 kbps: You must reserve a minimum of 5% bandwidth for class-default on T1 interface.



CHAPTER 9

Interworking Multiservice Gateway Access Circuit Redundancy

Table 27: Feature History

Feature Name	Release Information	Description
Interworking Multiservice Gateway Access Circuit Redundancy (iMSG ACR) support for ASR 900 1-Port OC-192 or 8-Port Low Rate CEM 20G Bandwidth Interface Module (A900-IMA1Z8S-CXMS)	Cisco IOS XE Amsterdam 17.3.1	The iMSG ACR feature is supported on serial interfaces for SONET and SDH ACR on the Cisco ASR RSP3 module. DCC and MS features are also supported.

Interworking Multiservice Gateway Access Circuit Redundancy (iMSG ACR) enables local switching for serial interfaces by creating a virtual serial-ACR interface. All configuration changes made on the virtual serial-ACR interface are applied automatically on both the working and protect interfaces. Switching from working to protect or protect to working interface occurs within 250 milliseconds at different scaled levels with line rate traffic. For more information, see Serial Interfaces.

Note Interworking Multiservice Gateway Access Circuit Redundancy (iMSG ACR) is supported on Cisco ASR 900 RSP2 and RSP3 modules from Cisco IOS XE Everest 16.5.1 release.

- SONET Supported Modes, on page 185
- SDH Supported Modes , on page 186
- Restrictions for iMSG ACR, on page 187
- How to Configure iMSG ACR, on page 187

SONET Supported Modes

Table 28: SONET Supported Modes for iMSG ACR

Mode	Ports
STS-3C	OC-3, OC-12, OC-48

Mode	Ports
DS3	OC-3, OC-12, OC-48
DS3-T1	OC-3, OC-12, OC-48
VT 1.5	OC-3, OC-12, OC-48

Table 29: SONET Supported Modes for iMSG non-ACR

Mode	Ports
STS-3C	OC-3, OC-12, OC-48
STS-12C	OC-12, OC-48
STS-48C	OC-48
DS3	OC-3, OC-12, OC-48
DS3-T1	OC-3, OC-12, OC-48
VT 1.5	OC-3, OC-12, OC-48

SDH Supported Modes

Table 30: SDH Supported Modes for iMSG ACR

Mode	Ports
VC4	STM1, STM4, STM16
TUG-3-E3	STM1, STM4, STM16
TUG-3-T3	STM1, STM4, STM16
TUG-2-E1	STM1, STM4, STM16
TUG-2-T1	STM1, STM4, STM16

Table 31: SDH Supported Modes for iMSG non-ACR

Mode	Ports
VC4	STM1, STM4, STM16
VC4-4c	STM4, STM16
VC4-16c	STM16

Modes not supported on SDH for iMSG ACR

- VC4—TUG-3—TUG-2—VC-12
- VC4— TUG-3—TUG-2—VC-11
- (AU-3) VC-3—TUG-2—VC-12
- (AU-3) VC-3—TUG-2—VC11
- SDH—AU3—VC12—E1

Restrictions for iMSG ACR

Table 32: Feature History

Feature Name	Release	Description
Interworking Support for nxDS0	Cisco IOS XE Amsterdam 17.3.1	Interworking function (IWF) for PPP/HDLC is supported on Ethernet for E1/STM1 ports. This support is extended at nxDS0 level to speed up the GSR TDM migration.

- A maximum number of 336 circuits are supported on ACR interface.
- Quality of Service (QoS) and default experimental bits (EXP) marking for MPLS pseudowires is not supported on the iMSG-ACR interface.
- The iMSG ACR is supported only on A900-IMA3G-IMSG card.
- Port license must be enabled on 3G IM port SONET or SDH ports.
- For iMSG IPv6 MTU, the change in configuring MTU value is not supported. Ensure that you configure the circuit with the default MTU value.

How to Configure iMSG ACR

Creating ACR Group

You can create virtual ACR groups with the following SONET ACR types:

- OC3
- OC12
- OC48

You can create virtual ACR groups with the following SDH ACR types:

- STM1
- STM4
- STM16

To create ACR group, enter the following commands:

```
rotuer(config)#ACR <id> type <type-id>
```

Configuring ACR Group on APS

You can configure ACR group on APS. The ACR group supported range is from 1 to 96. Any group number exceeding the range is not supported. You can configure the interface as working using the circuit number. The circuit number identies a particular channel in the APS pair. Since the interface only supports 1 + 1 redundancy, the only valid and the default value for working interface is 1.

The APS group created can be active or inactive:

- Active—The interface that is currently sending and receiving data.
- Inactive—The interface that is currently standing by to take over when the active fails.



Note APS is supported in revertive and non-revertive mode and can be configured as undirectional and bidirectional.

To configure ACR group on APS with SONET interface as a working interface, enter the following commands:

```
configure terminal
controller sonet slot/subslot/port
aps group acr-id
aps working circuit-number
 aps group acr <acr_id>
```

To configure ACR group on APS with SDH interface as a working interface, enter the following commands:

```
configure terminal
controller sdh slot/subslot/port
aps group acr-id
aps working circuit-number
 aps group acr <acr_id>
```

You can configure an interface to be protect interface in the APS pair. Because only 1+1 redundancy is supported, the only valid value is 1, and the protect interface defaults to 1.

While specifying ACR ID, you need to specify an IP address for the loopback interface. The protect interface uses this IP address to communicate with the working interface.

To configure ACR group on APS with SONET interface as a protect interface, enter the following commands:

```
configure terminal
controller sonet slot/subslot/port
aps group acr-id
aps protect <acr_id> <any-loopback-ip-address>
 aps group acr <acr_id>
```

To configure ACR group on APS with SDH interface as a protect interface, enter the following commands:

```
configure terminal
controller sdh slot/subslot/port
```

```
aps group acr-id
aps protect <acr_id> <any-loopback-ip-address>
 aps group acr <acr_id>
```

The following example explains how to configure ACR group on APS with SONET interface as working interface:

```
Router# configure  terminal
Router (config)# controller sonet  0/1/0
Router(config-controller)# aps  group  1
Router (config-controller)# aps  working  1
Router (config-controller)# aps group acr 1
```

The following example explains how to configure ACR group on APS with SONET interface as protect interface:

```
Router# configure  terminal
Router (config)# controller  sonet  0/2/0
Router(config-controller)# aps  group  1
Router (config-controller)# aps protect  1 10.1.1.1
Router (config-controller)# aps group acr 1
```

The following example explains how to configure ACR group on APS with SDH interface as working interface:

```
Router# configure  terminal
Router (config)# controller sdh  0/3/0
Router(config-controller)# aps  group  1
Router (config-controller)# aps  working  1
Router (config-controller)# aps group acr 1
```

The following example explains how to configure ACR group on APS with SDH interface as protect interface:

```
Router# configure  terminal
Router (config)# controller  sdh  0/4/0
Router(config-controller)# aps  group  1
Router (config-controller)# aps protect  1 10.1.1.1
Router (config-controller)# aps group acr 1
```

Creating Serial Interface for SONET ACR

You can create serial interface for SONET ACR on VT 1.5, CT-3, and T3 modes.

Creating Serial Interface for SONET ACR on VT 1.5 Mode

To create serial interface for SONET ACR on VT 1.5 mode, enter the following commands:

```
controller SONET-ACR <ACR-ID>
 sts-1 1
 mode vt-15
 vtg <vtg_num> t1 <t1_num> channel-group <channel_num> timeslots 1-24
 vtg <vtg_num> t1 <t1_num> channel-group <channel_num> timeslots 1
```

The following example describes how to create serial interface on VT 1.5 mode for SONET controller:

```
controller SONET-ACR 100
 sts-1 2
```

```
 mode vt-15
 vtg 1 t1 1 channel-group 0 timeslots 1-24
 vtg 2 t1 2 channel-group 1 timeslots 1
```

Creating Serial Interface for SONET ACR on CT3 Mode

To create serial interface for SONET ACR on CT-3 mode, enter the following commands:

```
controller SONET-ACR <ACR-ID>
 sts-1 1
 mode ct3
 t3 framing c-bit
 t1 <t1_num> channel-group <channel_num> timeslots 1-24
```

The following example describes how to create serial interface on CT-3 mode for SONET controller:

```
controller SONET-ACR 100
  sts-1 1
  mode ct3
  t3 framing c-bit
  t1 1 channel-group 0 timeslots 1-24
```

Creating Serial Interface for SONET ACR on T3 Mode

To create serial interface for SONET ACR on T3 mode, enter the following commands:

```
controller SONET-ACR <ACR-ID>
 sts-1 3
 mode t3
 t3 framing c-bit
 t3 channel-group 0
```

The following example describes how to create serial interface on T3 mode for SONET controller:

```
controller SONET-ACR 100
 sts-1 3
  mode t3
  t3 framing c-bit
  t3 channel-group 0
 !
```

Creating Serial Interface for SONET ACR on PoS Mode

To create serial interface for SONET ACR on PoS mode, enter the following commands

```
controller SONET-ACR 50
 sts-1 1 - 3 mode sts-3c
  channel-group 0
```

Creating Serial Interface for SONET non-ACR on PoS Mode

To create serial interface for SONET non-ACR on STS-12c mode, enter the following commands:

```
configure terminal
controller SONET <slot>/<subslot>/<port>
   rate OC12
   sts-1 1 - 12 mode sts-12c
   channel-group 0
```

To create serial interface for SONET non-ACR on STS-48c mode, enter the following commands:

```
configure terminal
controller SONET <slot>/<subslot>/<port>
  rate OC48
  sts-1 1 - 48 mode sts-48c
  channel-group 0
```

Creating Serial Interface for SDH ACR

To create serial interface for SDH ACR on T1, enter the following commands:

```
configure terminal
controller sdh-acr <acr-ID>
aug mapping au-4
au-4 1
mode tug-3
tug-3 1
mode vc1x
Tug-2 1 payload vc12
t1 1 channel-group 0 timeslots 1 - 24
```

To create serial interface for SDH ACR on E1, enter the following commands:

```
enable
configure terminal
controller sdh-acr 200
aug mapping au-4
au-4 1
mode tug-3
tug-3 1
mode vc1x
Tug-2 1 payload vc12
e1 1 channel-group 0 timeslots 1 - 31
```

The following example explains how to create serial interface for SDH ACR on T1:

```
configure terminal
controller sdh-acr 200
aug mapping au-4
au-4 1
mode tug-3
tug-3 1
mode vc1x
Tug-2 1 payload vc12
t1 1 channel-group 0 timeslots 1 - 24
```

The following example explains how to create serial interface for SDH ACR on E1:

```
enable
configure terminal
```

```
controller sdh-acr 300
aug mapping au-4
au-4 1
mode tug-3
tug-3 1
mode vc1x
Tug-2 1 payload vc12
e1 1 channel-group 0 timeslots 1 - 31
```

Creating Serial Interface for SDH ACR on PoS Mode

To create serial interface for SDH ACR on PoS mode, enter the following commands

```
controller SDH-ACR 50
 aug mapping au-4
 au-4 1
  mode vc4
  Channel-group 0
```

Creating Serial Interface for SDH non-ACR on PoS Mode

To create serial interface for SDH non-ACR on VC4-4c Mode, enter following commands under physical controller:

```
configure terminal
controller SDH <slot>/<subslot>/<port>
  rate STM
  au-4 1 - 4 mode vc4-4c
   channel-group 0
```

To create serial interface for SDH non-ACR on VC4-16c Mode, enter following commands under physical controller:

```
configure terminal
controller SDH <slot>/<subslot>/<port>
  rate STM16
  au-4 1 - 16 mode vc4-16c
  channel-group 0
```

Modifying Encapsulation to PPP

By default the encapsulation is HDLC, and you can change the encapsulation to PPP.

To modify encapsulation to PPP, enter the following commands:

```
router(config)#interface SERIAL-ACR148.1
router(config-if)#no ip address
router(config-if)# encapsulation ppp
```

Configuring IPv4 and IPv6 Interworking Pseudowire

To configure IPv4 interworking pseudowire class, enter the following commands:

```
pseudowire-class <PW_class_name>
```

```
 encapsulation mpls
 interworking ip
 control-word
```

To configure IPv6 interworking pseudowire interface, enter the following commands:

```
interface pseudowire<pw-number>
 encapsulation mpls
 neighbor <peer-address> <vcid-value>
 control-word include
```



Note Based on the far-end router, the control-word needs to be enabled or disabled.

The following example describes how to configure IPv4 interworking pseudowire class:

```
pseudowire-class PW_class_name
 encapsulation mpls
 interworking ip
 control-word
```

The following example describes how to configure IPv6 interworking pseudowire interface:

```
interface pseudowire30
 encapsulation mpls
 neighbor 10.2.2.2 30
 control-word include
```

Configuring Cross-Connect on Serial Interface

The **xconnect** command binds the attachment circuit to a pseudowire for cross connect service. The identifier creates the binding between a pseudowire that is configured on a PE router and an attachment circuit in a CE device.

To perform IPv4 cross connection between a pseudowire and attachment circuit, use the following commands:

```
router(config)#interface serial-ACR1.29
router(config-if)#xconnect ip-address vc_num pw-class  class-name
```

To perform IPv6 cross connection between a pseudowire and attachment circuit, use the following commands:

```
router(config)#l2vpn xconnect context <xconnect name>
router(config-xconnect)#interworking ipv6
router(config-xconnect)#member pseudowire pw-number
router(config-xconnect)#member serial-ACR
```

The following example shows IPv6 cross connection between a pseudowire and attachment circuit:

```
l2vpn xconnect context pw_30_acr_vt15
interworking ipv6
member pseudowire30
member serial-ACR1.29
```

Verifying iMSG ACR

Verifying iMSG ACR with HDLC Encapsulation

Use the following **show aps group** and **show interface SERIAL-ACR** commands to verify iMSG ACR with HDLC encapsulation on the SONET or SDH controller:

```
router# show aps group 100
SONET 0/1/16 APS Group 100: protect channel 0 (Inactive) (HA)
        Working channel 1 at 10.1.1.3 (Enabled)  (HA)
        unidirectional, ADM, non-revertive
        PGP timers (extended for HA): hello time=1; hold time=10
                hello fail revert time=120
        SONET framing; SONET APS signalling by default
        Received K1K2: 0x11 0x04
                Do Not Revert (working)
        Transmitted K1K2: 0x00 0x04
                No Request (Null)
        Remote APS configuration: (null)

SONET 0/4/16 APS Group 100: working channel 1 (Active) (HA)
        Protect at 10.1.1.3 (unidirectional, non-revertive)
        PGP timers (from protect): hello time=1; hold time=10
        SONET framing
        Remote APS configuration: (null)


router# show aps group 300
SDH 0/3/0 APS Group 300: protect channel 0 (Inactive) (HA)
        Working channel 1 at 10.1.1.3 (Enabled)  (HA)
        unidirectional, ADM, non-revertive
        PGP timers (extended for HA): hello time=1; hold time=10
                hello fail revert time=120
        SDH framing; SDH APS signalling by default
        Received K1K2: 0x11 0x04
                Do Not Revert (working)
        Transmitted K1K2: 0x00 0x04
                No Request (Null)
        Remote APS configuration: (null)

SDH 0/3/1 APS Group 300: working channel 1 (Active) (HA)
        Protect at 10.1.1.3 (unidirectional, non-revertive)
        PGP timers (from protect): hello time=1; hold time=10
        SDH framing
        Remote APS configuration: (null)


router#show interface SERIAL-ACR100.1
SERIAL-ACR100.1 is up, line protocol is up
  Hardware is N/A
  MTU 1500 bytes, BW 1536 Kbit/sec, DLY 20000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation HDLC, crc 16, loopback not set
  Keepalive set (10 sec)
  Last input 00:00:05, output 00:00:02, output hang never
  Last clearing of "show interface" counters never
  Input queue: 0/375/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: fifo
  Output queue: 0/40 (size/max)
  30 second input rate 0 bits/sec, 0 packets/sec
  30 second output rate 0 bits/sec, 0 packets/sec
     70 packets input, 10902 bytes, 0 no buffer
```

```
     Received 0 broadcasts (0 IP multicasts)
     0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     57 packets output, 2508 bytes, 0 underruns
     0 output errors, 0 collisions, 0 interface resets
     20 unknown protocol drops
     0 output buffer failures, 0 output buffers swapped out
     7 carrier transitions no alarm present
  VC 1: timeslot(s): 1-24, Transmitter delay 0, non-inverted data
```

Use the following **show interface SERIAL-ACR** commands to verify HDLC ACR configuration on the SDH controller:

```
router#show int SERIAL-ACR148.1
SERIAL-ACR148.1 is up, line protocol is up
  Hardware is N/A
  MTU 1500 bytes, BW 44210 Kbit/sec, DLY 20000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation HDLC, crc 16, loopback not set
  Keepalive set (10 sec)
  Last input 00:00:07, output 00:00:06, output hang never
  Last clearing of "show interface" counters 01:16:15
  Input queue: 0/375/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: fifo
  Output queue: 0/40 (size/max)
  30 second input rate 0 bits/sec, 0 packets/sec
  30 second output rate 0 bits/sec, 0 packets/sec
     122925 packets input, 16492939 bytes, 0 no buffer
     Received 0 broadcasts (0 IP multicasts)
     0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     744239 packets output, 41162791 bytes, 0 underruns
     0 output errors, 0 collisions, 0 interface resets
     85 unknown protocol drops
     0 output buffer failures, 0 output buffers swapped out
     0 carrier transitions alarm present
  DSU mode 0, bandwidth 0 Kbit, scramble 0, VC 1, non-inverted data
```

Verifying iMSG ACR with PPP Encapsulation

Use the following **show interface SERIAL-ACR** command to verify iMSG ACR with PPP encapsulation on the SONET or SDH controller:

```
router#show interface SERIAL-ACR100.1
SERIAL-ACR100.1 is up, line protocol is up
  Hardware is N/A
  MTU 1500 bytes, BW 1536 Kbit/sec, DLY 20000 usec,
     reliability 255/255, txload 2/255, rxload 2/255
  Encapsulation PPP, LCP Open
  Stopped: TAGCP
  Open: IPCP, crc 16, loopback not set
  Keepalive set (10 sec)
  Last input 00:00:00, output 00:00:00, output hang never
  Last clearing of "show interface" counters 03:28:29
  Input queue: 0/375/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: fifo
  Output queue: 0/40 (size/max)
  5 minute input rate 14000 bits/sec, 1185 packets/sec
  5 minute output rate 14000 bits/sec, 1185 packets/sec
     14628274 packets input, 25965577 bytes, 0 no buffer
     Received 0 broadcasts (0 IP multicasts)
```

```
     0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     14628402 packets output, 26013374 bytes, 0 underruns
     0 output errors, 0 collisions, 1 interface resets
     0 unknown protocol drops
     0 output buffer failures, 0 output buffers swapped out
     2 carrier transitions
 PW stats
 14625804 input packets ,14625930 output packets,
 1872102912 input bytes, 1872119040 output bytes, 0 input packet drop
 no alarm present
  VC 1: timeslot(s): 1-24, Transmitter delay 0, non-inverted data
```

Verifying iMSG ACR with HDLC Encapsulation on PoS Mode

Use the following **show interfaces SERIAL-ACR<*acr-id*>.<*path-number*>** command to verify iMSG ACR with HDLC encapsulation on PoS mode for SONET or SDH controller.

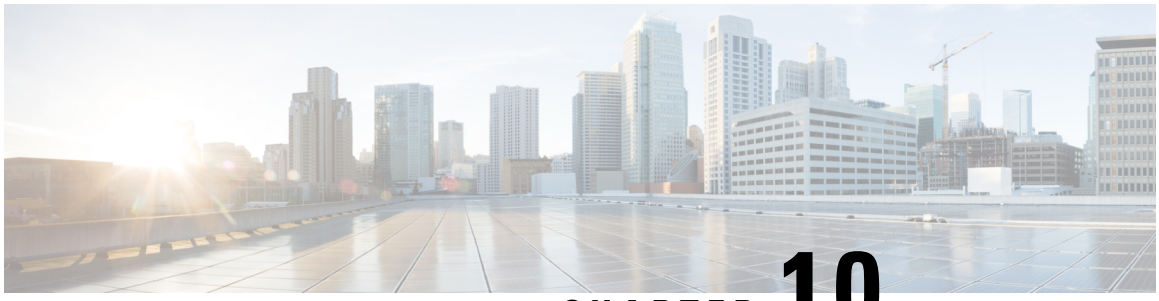
```
Router#show interfaces serial-acr50.1
SERIAL-ACR50.1 is up, line protocol is up
  Hardware is N/A
  MTU 1500 bytes, BW 155000 Kbit/sec, DLY 100 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation HDLC, crc 16, loopback not set
  Keepalive set (10 sec)
  Last input 00:00:09, output 00:00:05, output hang never
  Last clearing of "show interface" counters 00:00:27
  Input queue: 0/375/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: fifo
  Output queue: 0/40 (size/max)
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     102 packets input, 10688 bytes
     Received 0 broadcasts (0 IP multicasts)
     0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     103 packets output, 10732 bytes, 0 underruns
     0 output errors, 0 collisions, 0 interface resets
     0 unknown protocol drops
     0 output buffer failures, 0 output buffers swapped out
     0 carrier transitions
PW stats
100 input packets ,100 output packets,
10000 input bytes, 10000 output bytes, 0 input packet drop
no alarm present
  VC:1, Non-inverted data
```

Verifying iMSG ACR with PPP Encapsulation on PoS Mode

Use the following **show interfaces SERIAL-ACR<*acr-id*>.<*path-number*>** command to verify iMSG ACR with PPP encapsulation on PoS mode for SONET or SDH controller.

```
Router#show interfaces serial-acr50.85
SERIAL-ACR50.85 is up, line protocol is up
  Hardware is N/A
  MTU 1500 bytes, BW 155000 Kbit/sec, DLY 100 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation PPP, LCP Open
  Stopped: TAGCP
```

```
  Open: IPCP, crc 16, loopback not set
  Keepalive set (10 sec)
  Last input 00:00:01, output 00:00:01, output hang never
  Last clearing of "show interface" counters 00:00:11
  Input queue: 0/375/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: fifo
  Output queue: 0/40 (size/max)
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     104 packets input, 10776 bytes
     Received 0 broadcasts (0 IP multicasts)
     0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     104 packets output, 10776 bytes, 0 underruns
     0 output errors, 0 collisions, 0 interface resets
     0 unknown protocol drops
     0 output buffer failures, 0 output buffers swapped out
     0 carrier transitions
PW stats
100 input packets ,100 output packets,
10000 input bytes, 10000 output bytes, 0 input packet drop
no alarm present
  VC:85, Non-inverted data
```



CHAPTER 10

Multilink Interfaces

Starting with Cisco IOS XE Amsterdam 17.1.x, the router supports configuring the multilink interfaces.

- MLPPP, on page 199
- MLPPP Interworking, on page 202
- MLPPP Layer 3 Termination, on page 206
- MLPPP ACR Support for iMSG, on page 207
- Multilink PPP Minimum Links Mandatory, on page 208
- Multilink Frame Relay, on page 209
- Multilink Frame Relay Layer 3 Termination, on page 214
- Multilink Frame Relay End-to-End Mode, on page 218

MLPPP

The Multilink Point-to-Point (MLPPP) feature enables you to create multilinks using an LCP option negotiation between two end points. The router A indicates to its peer router B that it is capable of combining multiple physical links into a logical bundle. Once the LCP negotiation is complete, the router A sends the multilink option to the router B and creates multilinks.

Starting with Cisco IOS XE 17.1.x, Multiprotocol Label Switching (MPLS) is supported over Multilink PPP (MLP) links in an access interface.

Restrictions for MLPPP

- MLPPP bundle is supported only on the RSP3 3G module.
- The MLPPP bundle should have member links only from the same interface module, if the member link is from different interface modules such as T1, E1, or OCx, then the MLPPP isn't supported.
- Each router supports up to a maximum of 1020 channels, hence a maximum number of bundles that can be configured is up to 510 until Cisco IOS XE Bengaluru 17.4.1.
- The change of encapsulation isn't supported if the member link is part of the multilink bundle.
- The maximum number of links in the bundle is 16.
- L3 termination isn't supported.

- The PPP options such as endpoint and member links are supported, and the options such as fragmentation, fragment-delay, inter-leave, idle link, multiclass, and change in MRRU value aren't supported.
- The MLPPP bundle can have either T1 or E1 links. It can't have a combination of T1 type and E1 type links.
- One MLPPP bundle can contain links belonging to a single interface module.
- The MLPPP bundle ID number that is supported is from 1 through 511 only.
- Fragmentation isn't supported.
- NCP, queue, and slippage aren't supported.
- Change in MRRU and MTU values on multilink interface isn't supported.
- The maximum number of multilink (max-link) configuration is supported in the MLPPP bundle. If the max-link value is configured as five, then the five links are active in the bundle. If one of five active links goes down, then there's no back-up link to become active.
- The member links of the MLPPP bundle can't be combined from different port types such as T1, T3, and SONET.
- Multiport isn't supported for MLPPP.

How to Configure MLPPP

Configuring MLPPP

To create the MLP interface, enter the following commands:

```
router(config)#interface multilink <group_number>
```



Note From release Cisco IOS XE Cupertino 17.9.1, the multilink group number range is restricted to only to 1–1024 for the following interface modules:

- ASR 900 1-Port OC-192 or 8-Port Low Rate CEM 20G Bandwidth (A900-IMA1Z8S-CXMS)
- 1-port OC-48/STM-16 or 4-port OC-12/OC-3 / STM-1/STM-4 + 12-port T1/E1 + 4-port T3/E3 CEM (A900-IMA3G-IMSG)

No changes in the multilink group number range for other interface modules, as it remains the same with 1–65535.

To add a PPP member to the channel, use the **ppp multilink group <group_number>** command. This command binds the serial interface with the corresponding multilink number (it typically adds the interface to the multilink). The PPP timeout retry should be added under the link if it's a part of the MLPPP ACR bundle.

The same configuration should be performed on the CE bundle links serial interface.

```
interface serial x/y/z.<channel_id>
    encapsulation ppp
```

```
ppp multilink group  <group_number>
ppp timeout retry 1
```

Two keys define the identity of a remote system: the PPP username and Multilink PPP endpoint discriminator. PPP authentication mechanisms (for example, password authentication protocol [PAP] or Challenge-Handshake Authentication Protocol [CHAP]) learn the PPP username. The endpoint discriminator is an option negotiated by the Link Control Protocol (LCP). Therefore, a bundle consists of links that have the same PPP usernames and endpoint discriminators.

The multilink group number is local to the system. However, for links to be a part of the bundle, the end-point discriminator helps to correctly identify which bundle the link needs to be part of. This end-point discriminator needs to be the same on both ends of the multilink.

```
interface serial<interface-name>
ppp multilink group <>
ppp multilink endpoint string <unique string>
```

The following example shows how to configure multilink interface:

```
interface multilink 30
ppp multilink endpoint string T1_multilink
interface serial0/3/4.1
encapsulation ppp
ppp multilink group 30
ppp timeout retry 1
```

Configuring MLPPP ACR

To create the MLP interface, enter the following commands:

```
router(config)#interface multilink <group_number>
```

To configure MLPPP ACR, enter the following commands:

The PPP timeout retry should be added under the link if it is a part of the MLPPP ACR bundle.

The same configuration should be performed on the CE bundle links serial interface.

```
serial-acr<group number.channel id>
encapsulation ppp
ppp multilink group  <group_number>
ppp timeout retry 1
```

The following example shows how to configure MLPPP ACR:

```
inter SERIAL-ACR3.1
encapsulation ppp
ppp multilink group 1
ppp timeout retry 1
```

For more information to create serial ACR interface, see iMSG ACR.

Deleting Serial Interface from an Active MLPPP Bundle

To remove a serial interface from the member link bundle, perform the following steps:

1. Shut the member link and ensure that the serial interface moves to down state on the other side of the bundle.

2. Remove the serial interface link from the MLPPP bundle using the **no ppp multilink group <group-id>** command.

Removing MLPPP Configuration

To delete the MLPPP bundle, you need to remove the serial interfaces linked to the bundle, and then remove link from the the serial interfaces.

To delete the MLPPP bundle, enter the following commands:

```
Router#configure terminal
router(config)#interface multilink <group_number>
router(config)#interface serial x/y/z.<channel_id>
router(config-if)#no ppp multilink group <multilink-id>
router(config-if)#no ppp multilink
```

To delete the multilink interface, you need to shut the multilink interface, and then delete the interface.

To delete the multilink interface, enter the following commands:

```
Router#config terminal
Router(config)#interface multilink <multilink-id>
Router(config-if)#shutdown
Router(config-if)#exit
Router(config)#no interface multilink <multilink-id>
```

Verifying MLPPP Configuration

To view the multilink bundle status and describes all the bundle parameter and details, use the **Show ppp multilink active** command:

```
router#Show ppp multilink active
Bundle name: rsp3-vz-pe1
  Remote Endpoint Discriminator: [1] rsp3-vz-pe1
  Local Endpoint Discriminator: [1] ASR_1000_CE_1
  Bundle up for 00:07:00, total bandwidth 1536, load 1/255
  Receive buffer limit 12000 bytes, frag timeout 1000 ms
  Bundle is Distributed
    0/0 fragments/bytes in reassembly list
    0 lost fragments, 0 reordered
    0/0 discarded fragments/bytes, 0 lost received
    0x53 received sequence, 0x0 sent sequence
  Platform Specific Multilink PPP info
    NOTE: internal keyword not applicable on this platform
    Interleaving: Disabled, Fragmentation: Disabled
  Member links: 1 active, 0 inactive (max 16, min not set)
    Se0/1/0.1/1/1:1, since 00:07:00
```

MLPPP Interworking

The MLPPP interworking supports IPv4 or IPv6 Layer 2 VPN Interworking with T1 or E1 bundles on the Cisco RSP3 module.

The MLPPP interworking enables service providers (offering relatively low-speed links) to use MLP and spread traffic across them in their MPLS networks. The MPLS Multilink PPP feature reduces the number of Interior Gateway Protocol (IGP) adjacencies and facilitates load sharing of traffic.

The MLPPP creates bundle in the following manner:

- T1 and E1 members should be from the same interface module.
- T1 and E1 members should be of the same port type. For example, if MLPPP link is from the T1, E1, or OCx ports, then only the links from the respective T1, E1, or OCx ports can be bundled together.
- Supports a maximum of 510 MLPPP pseudowires per interface module and 510 MLPPP pseudowires per router.

The following table details the number of bundles created in a module.

Table 33: MLPPP Bundle Created for Cisco RSP3 Module:

Number of Links in a Bundle	Number of VLANs Used	Maximum Number of Bundles in Cisco RSP3 Module
1	2	1020/2 = 510
2	3	1020/3 = 340
16	17	1020/17 = 60

Restrictions for MLPPP Interworking

- The router supports links equal to T1 or E1 for MLPPP bundling. You cannot bundle high-speed links (for example, E3) as the interface module can store only 50 ms of data based on the E1 speed.
- Each MLPPP bundle supports up to a maximum of 16 member links.
- Each MLP Bundle can have serial links from the same interface module or port type only.
- The MTU value supported is 1500 and MRRU should be more than the value of MTU, which is 1504.
- The jumbo frames are not supported.
- The keepalive is based on the first serial link attached to the MLP bundle.

How to Configure MLPPP Interworking

Configuring L2VPN Interworking and Cross Connection under the Attachment Circuit for Multilink Interfaces

Configuring L2VPN Interworking

To configure L2VPN interworking, create a pseudowire class with the tunneling encapsulation as MPLS. The **interworking** command specifies the type of payload traffic that flows across the pseudowire tunnel. Configure pseudowire class only once on a device.

You can also configure **control-word** as an optional command.

To configure L2VPN interworking, use the following commands:

```
router>enable
router#configure terminal
router(config)#interface pseudowire pw-number
router(config-if)# encapsulation mpls
router(config-if)# neighbor <peer-address><vcid-value>
router(config-xconnect)# control-word include
```

The following example shows how to configure L2VPN interworking:

```
interface pseudowire30
 encapsulation mpls
 neighbor 10.2.2.2 30
 control-word include
```

Configuring Cross-Connect Under Attachment Circuit

The **xconnect** command binds the attachment circuit to an L2VPN pseudowire for cross connect service.

The virtual circuit identifier creates the binding between a pseudowire that is configured on a PE router and an attachment circuit in a CE device.

To perform IPv4 cross connection between an AToM routed pseudowire and attachment circuit, use the following commands:

```
router(config)#l2vpn xconnect context xconnect-name
router(config-xconnect)#interworking ip
router(config-xconnect)#member pseudowire pw-number
router(config-xconnect)#member multilink <multilink-id>
```

To perform IPv6 cross connection between an AToM routed pseudowire and attachment circuit, use the following commands:

```
router(config)#l2vpn xconnect context xconnect-name
router(config-xconnect)#interworking ipv6
router(config-xconnect)#member pseudowire pw-number
router(config-xconnect)#member multilink <multilink-id>
```

The following example shows how to configure IPv6 interworking and cross connection under the attahment circuit for multilink interfaces:

```
l2vpn xconnect context temp
interworking ipv6
member Multilink1
member Pseudowire 1
```

Verifying L2VPN Interworking and Cross-Connect Configuration

You can verify L2VPN interworking configuration using the following **show** commands:

- **show mpls l2 vc <vc-id> detail**
- **show xconnect all**—Displays cross connect configuration.

- **show interfaces serial <interface-name>**—Provides interface details such as encapsulation, loopback, payload, MTU, bandwidth, and so on for a specific port.

```
router#show interfaces serial0/1/12.1
Serial0/1/12.1 is down, line protocol is down
  Hardware is unknown
  MTU 1500 bytes, BW 44210 Kbit/sec, DLY 20000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation HDLC, crc 16, loopback not set
  Keepalive set (10 sec)
  Last input never, output never, output hang never
  Last clearing of "show interface" counters never
  Input queue: 0/375/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: fifo
  Output queue: 0/40 (size/max)
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     0 packets input, 0 bytes, 0 no buffer
     Received 0 broadcasts (0 IP multicasts)
     0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     0 packets output, 0 bytes, 0 underruns
     0 output errors, 0 collisions, 1 interface resets
     0 unknown protocol drops
     0 output buffer failures, 0 output buffers swapped out
     0 carrier transitions alarm present
  DSU mode 0, bandwidth 0 Kbit, scramble 0, VC 3, non-inverted data
```

```
router#show xconnect all
Legend: XC ST=Xconnect State S1=Segment1 State S2=Segment2 State
UP=Up DN=Down AD=Admin Down IA=Inactive
SB=Standby HS=Hot Standby RV=Recovering NH=No Hardware

XC ST Segment 1 S1 Segment 2 S2
------+---------------------------------+--+---------------------------------+--
DN pri mpls 10.2.2.2:30 DN ac Mu30(PPP) UP
```

MLPPP Layer 3 Termination

Table 34: Feature History

Feature Name	Release Information	Description
MLPPP IP Termination on all Serial Physical and Logical Interfaces	Cisco IOS XE Bengaluru 17.5.1	This release supports Layer 3 termination using IPv6 addressing on MLPPP interfaces for the 1 port OC-48/STM-16 or 4 port OC-12/OC-3 / STM-1/STM-4 + 12 port T1/E1 + 4 port T3/E3 CEM interface module. In releases earlier, with IPv4 addressing, you can scale up to 512 MLPPP bundles. Now with IPv6 addressing, the MLPPP bundles can be scaled up to 1024.

Starting with Cisco IOS XE Bengaluru 17.5.1, you can perform Layer 3 termination using IPv6 addressing on MLPPP interfaces on Cisco RSP3 modules. In releases earlier, with IPv4 addressing, you can scale up to 512 MLPPP bundles. Now with IPv6 addressing, the MLPPP bundles can be scaled up to 1024.

Restrictions for MLPPP Layer 3 Termination

- In the Cisco IOS XE Bengaluru 17.5.1, the maximum number of Layer 3 MLPPP interfaces that are supported is 1000.
- MTU cannot be configured on the MLPPP bundle, and can be configured only on individual members.
- NxDS0 serial interfaces cannot be part of the MLPPP bundle.
- Starting with Cisco IOS XE Bengaluru 17.5.1, when you scale up MLPPP, ensure that you use the following commands under the interface:
  - **ppp timeout retry** <*retry no*>
  - **keepalive** <*keepalive no*>

How to Configure MLPPP Layer 3 Termination

Configuring MLPPP Layer 3 Termination

To configure MLPPP Layer 3 termination, use the following commands:

```
router#configure terminal
router(config)#interface Multilink multilinkno
router(config-if)#ip address ip-address subnetmask
router(config-if)#commit
```

The following example shows how to configure MLPPP Layer 3 termination for IPv4 address:

```
router#configure terminal
router#interface Multilink 1001
router#ip address 10.10.10.1 255.0.0.0
```

The following example shows how to configure MLPPP Layer 3 termination for IPv6 address:

```
router#configure terminal
router#interface Multilink 1001
router#ipv6 address 4001:1::2/64
```

MLPPP ACR Support for iMSG

Table 35: Feature History

Feature Name	Release Information	Description
MLPPP ACR support for IPv4 or IPv6 Interworking Multiservice Gateway (iMSG)	Cisco IOS XE Amsterdam 17.3.1	MLPPP ACR is supported for IPv4 or IPv6 iMSG on the Cisco ASR RSP3 module. The restrictions for MLPPP interworking are applicable to iMSG ACR.

Starting with release Cisco IOS XE Cupertino 17.9.1, MLPPP bundle is supported on the RSP3 modules, only for TDM Interfaces.

For more information on supported modes and configuration, see iMSG ACR.

Restriction for MLPPP ACR

- The MLPPP ACR is supported only on the RSP3 3G module.
- Each router supports upto a total of 510 serial ACR interfaces. Hence, a total of 255 bundles can be configured, provided each MLPPP bundle has two links.
- Serial ACR and the other serial interface cannot be a part of the same bundle.
- Layer 3 termination not supported.
- A maximum number of links supported in an MLPPP bundle is 16.
- The change of encapsulation is not supported if the serial ACR interface is a part of the MLPPP bundle.

Note Restrictions for MLPPP interworking and iMSG ACR are applicable for MLPPP ACR.

Multilink PPP Minimum Links Mandatory

The Multilink PPP Minimum Links Mandatory feature enables you to configure the minimum number of links in a Multilink PPP (MLP) bundle required to keep that bundle active. You can enable this feature by entering the **ppp multilink min-links links mandatory** command. When you configure this command, all Network Control Protocols (NCPs) for an MLP bundle are disabled until the MLP bundle has the required minimum number of links. When a new link is added to the MLP bundle that brings the number of links up to the required minimum number of links, the NCPs are activated for the MLP bundle. When a link is removed from an MLP bundle, and the number of links falls below the required minimum number of links for that MLP bundle, the NCPs are disabled for that MLP bundle

How to Configure Multilink PPP Minimum Links Mandatory

Configuring Multilink PPP Minimum Links Mandatory

Before configuring multilink PPP minimum links mandatory, ensure that PPP and MLPPP are configured.

To configure the minimum number of links in an MLP bundle required to keep the bundle active, enter the following commands:

```
Router(config-if)#interface multilink multilink-id
Router(config-if)#ppp multilink links minimum <nooflinks> mandatory
```

The following example shows the multilink PPP minimum links mandatory configuration:

```
interface multilink 3
ppp multilink
ppp multilink min-links 5 mandatory
```

Verifying the Multilink PPP Minimum Links Mandatory Configuration

To verify the multilink PPP minimum links mandatory configuration, use the following **show** commands:

- **show running-config [interface type number] [linenum]**—Displays the contents of the currently running configuration file or the configuration for a specific interface, or map class information.
- **show interfaces multilink group-number**—Displays statistics for the specified multilink bundle.
- **show ppp multilink**—Displays information about all existing multilink bundles and their member links.
- **show interfaces multilink group-number stat**—Displays traffic statistics for a multilink bundle.

```
Router# show run int multilink 10
.
.
.Building configuration...

Current configuration : 160 bytes
!
interface Multilink10
no ip address
ppp multilink
```

```
ppp multilink links minimum 3 mandatory
ppp multilink group 10
ppp multilink endpoint string TEST
end
```

Multilink Frame Relay

Table 36: Feature History

Feature Name	Release Information	Description
Multilink Frame Relay (MFR) for IP Interworking	Cisco IOS XE Dublin 17.10.1	You can configure MFR encapsulation on serial interface for IPv4 and IPv6 interworking for the following interface modules: • One port OC-48/STM-16 or 4 port OC-12/OC-3 / STM-1/STM-4 + 12 port T1/E1 + 4 port T3/E3 CEM Interface Module (A900-IMA3G-IMSG) • 1-Port OC-192 or 8-Port Low Rate CEM 20G Bandwidth Interface Module (A900-IMA1Z8S-CXMS) Multiple physical interfaces can be combined into a single bundle, and this frame relay interface supports more bandwidth than that is available from any single physical interface. The ease to add or remove physical interfaces dynamically so that you can modify the total bandwidth available on that interface. The resilience that is provided when multiple physical interfaces are provisioned on a single bundle so that when some of the physical interfaces fail, the bundle continues to support the frame relay service.

MFR for the User-to-Network Interface (UNI) and Network-to-Network Interface (NNI) provides physical interface emulation for frame relay devices. The emulated physical interface consists of one or more physical links that are aggregated into a single bundle of bandwidth. This service provides a frame-based inverse multiplexing function and solves most of the following problems on user-to-network in a frame relay network:

- Lack of required bandwidth availability due to facility constraints (for example, there is no E3/T3 service in a geographical region), or service offering restrictions (for example, there is no fractional E1/T1 service).
- The physical interface as an inflexible pool of bandwidth
- The physical interface as a single point of failure on the frame relay interface

MFR configuration is supported on the following controllers:

- T1 or E1
- T3 or E3
- SONET (CT-3 and VT-15 modes only)
- SDH (VC-1x mode only)

Limitations of IP Interworking on MFR Interfaces

- Sub interface with point-to-multipoint is not supported. Only point-to-point is supported.
- QoS, fragmentation, and interleaving are not supported.
- Sub interface number and DLCI number should be same for connect and cross connect scenarios.
- Local connect is supported with IETF only, not with CISCO (default).
- Local connect protection is not supported.
- Functional operations, for example shut or no shut, on sub interface are not supported.
- The **l2vpn** command-line interface (CLI) is not supported.
- MFR is not supported on the STS-1e mode.
- Changing configuration from FR to MFR is not supported. First, you should remove all the existing FR configurations and then reconfigure with MFR.

How to Configure IP Interworking on MFR Interface

Configuring MFR

To configure MFR, perform the following steps:

1. Configure a channel group.
2. Create an MFR interface.
3. Attach an MFR interface to a serial interface.
4. Configure an MFR sub interface.
5. Configure IPv4 or IPv6 profile (for example, serial_testipv4 or serial_testipv6).
6. Configure a cross-connection using sub interfaces.

The following example shows how to configure MFR.

In the example, interface MFR5 is created with the frame relay interface type as Data Communications Equipment (DCE) and Local Management Interface (LMI) type as Cisco. Once the MFR interface is created, this interface is attached to the serial interface 10/4/16.1. The MFR5 interface is attached to the serial interface SERIAL-ACR10.57. After this, the MFR sub interface MFR 5.100 is are created. Now, the pseudowire is created using the sub interface.

Configuring an MFR Interface and Attaching it to the Serial Interface, and and Configuring an MFR Sub Interface

```
router(config)#interface MFR 5
router(config-if)#no ip address
router(config-if)#frame-relay intf-type dce
router(config-if)#frame-relay lmi-type cisco
router(config-if)#end

router(config)#interface Serial0/4/16.1
router(config-if)#encapsulation frame-relay MFR5
router(config-if)#end

router(config)#interface MFR 5.100 point-to-point
router(config-if)#end
```

Configuring Local Connection using Sub Interface

IPv4

```
router(config)#connect mlfrsub21vlcv4 GigabitEthernet0/0/3 100 MFR1.100 100 interworking
ip
```

IPv6

```
router(config)#connect mlfrsub21vlcv6 GigabitEthernet0/0/3 150 MFR1.150 150 interworking
ipv6
```

Configuring a Cross-connection Using Sub Interfaces

IPv4

```
router(config)#connect mfr5_100 MFR5.100 100 l2transport
router(config-fr-pw-switching)#xconnect 3.3.3.3 100 encapsulation mpls pw-class
serial_testipv4
router(config-xconn)#end
```

IPv6

```
router(config)#connect mfr5_100 MFR5.100 100 l2transport
router(config-fr-pw-switching)#xconnect 3.3.3.3 100 encapsulation mpls pw-class
serial_testipv6
router(config-xconn)#end
```

You can verify the MFR configuration using the following **show xconnect all** command.

```
router#show xconnect all
Legend:    XC ST=Xconnect State  S1=Segment1 State  S2=Segment2 State
  UP=Up       DN=Down            AD=Admin Down      IA=Inactive
  SB=Standby  HS=Hot Standby     RV=Recovering      NH=No Hardware
```

```
XC ST  Segment 1                          S1 Segment 2                           S2
------+---------------------------------+--+-----------------------------------+--
UP pri   ac MF5.100:100(FR DLCI)          UP mpls 3.3.3.3:100             UP
```

Configuring MFR ACR

You can configure MFR with Access Circuit Redundancy (ACR) only on the SONET (CT-3 and VT-15 modes).

To configure MFR ACR, perform the following steps:

1. Create an MFR interface.
2. Attaching an MFR interface to a serial interface
3. Create an MFR sub interface.
4. Configure IPv4 or IPv6 profile (for example, serial_testipv4 or serial_testipv6).
5. Configure a cross-connection using sub interfaces.

The following is a sample configuration for MLFR ACR.

In the example, two interfaces MFR4 and MFR5 are created with the frame relay interface type as Data Communications Equipment (DCE). Once the MFR interfaces are created, these interfaces are attached to the serial ACR interfaces. The MFR4 interface is attached to the serial interface SERIAL-ACR10.29 and the MFR5 interface is attached to the serial interface SERIAL-ACR10.57. Once these interfaces are attached, the MFR sub interfaces are created, for example, MFR4.101 and MFR5.151. Now, the pseudowires are created between the sub interfaces.

Creating an MFR interface

```
router(config)#interface MFR4
router(config-if)#no ip address
router(config-if)#frame-relay intf-type dce
router(config-if)#end
!

router(config)#interface MFR5
router(config-if)#no ip address
router(config-if)#frame-relay intf-type dce
router(config-if)#end
!
```

Attaching an MFR Interface to Serial Interface

```
router(config)#interface SERIAL-ACR10.29
router(config-if)#no ip address
router(config-if)#encapsulation frame-relay MFR4
router(config-if)#end
!
router(config)#interface SERIAL-ACR10.57
router(config-if)#no ip address
router(config-if)#encapsulation frame-relay MFR5
router(config-if)#end
!
```

Creating an MFR Sub Interface

```
router(config)#interface MFR4.101 point-to-point
```

```
router(config-if)#end

router(config)#interface MFR5.151 point-to-point
router(config-if)#end
!
```

Configuring a Cross-connection using Sub Interfaces

```
router(config)#connect mfr_101 MFR4.101 101 l2transport
router(config-fr-pw-switching)#xconnect 3.3.3.3 101 encapsulation mpls pw-class
serial_testipv4
router(config-xconnect)#end
!
router(config)#connect mfr_151 MFR5.151 151 l2transport
router(config-fr-pw-switching)#xconnect 3.3.3.3 151 encapsulation mpls pw-class
serial_testipv6
router(config-xconnect)#end
!
```

Verifying MFR Configuration

Use the following **show** commands to verify the MFR configuration.

- **show interface serial**
- **show xconnect all**
- **show ip interface brief**
- **show interfaces MFR*mfr-id***
- **show frame-relay multilink MFR*mfr-id***

```
router#show interfaces MFR1
MFR1 is up, line protocol is up
  Hardware is Multilink Frame Relay bundle interface
  MTU 1500 bytes, BW 18432 Kbit/sec, DLY 20000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation FRAME-RELAY, loopback not set
  Keepalive set (10 sec)
  DTR is pulsed for 2 seconds on reset
  LMI enq sent  0, LMI stat recvd 0, LMI upd recvd 0
  LMI enq recvd 4330, LMI stat sent  4330, LMI upd sent  0, DCE LMI up
  LMI DLCI 1023  LMI type is CISCO  frame relay DCE
  Broadcast queue 0/64, broadcasts sent/dropped 0/0, interface broadcasts 0
  Last input 00:00:06, output never, output hang never
  Last clearing of "show interface" counters 12:03:41
  Input queue: 0/375/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: fifo
  Output queue: 0/120 (size/max)
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     108300 packets input, 1330362 bytes, 0 no buffer
     Received 0 broadcasts (0 IP multicasts)
     0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     108334 packets output, 1340642 bytes, 0 underruns
     Output 0 broadcasts (0 IP multicasts)
     0 output errors, 0 collisions, 0 interface resets
     0 unknown protocol drops
     0 output buffer failures, 0 output buffers swapped out
```

```
     0 carrier transitions


router#show frame-relay multilink MFR1
Bundle: MFR1, State = up, class = A, fragmentation disabled
 BID = MFR1
 Bundle links:
  Serial0/4/7.12, HW state = up, link state = Up, LID = Serial0/4/7.12
  Serial0/4/7.11, HW state = up, link state = Up, LID = Serial0/4/7.11
  Serial0/4/7.10, HW state = up, link state = Up, LID = Serial0/4/7.10
  Serial0/4/7.9, HW state = up, link state = Up, LID = Serial0/4/7.9
  Serial0/4/7.8, HW state = up, link state = Up, LID = Serial0/4/7.8
  Serial0/4/7.7, HW state = up, link state = Up, LID = Serial0/4/7.7
  Serial0/4/7.6, HW state = up, link state = Up, LID = Serial0/4/7.6
  Serial0/4/7.5, HW state = up, link state = Up, LID = Serial0/4/7.5
  Serial0/4/7.4, HW state = up, link state = Up, LID = Serial0/4/7.4
  Serial0/4/7.3, HW state = up, link state = Up, LID = Serial0/4/7.3
  Serial0/4/7.2, HW state = up, link state = Up, LID = Serial0/4/7.2
  Serial0/4/7.1, HW state = up, link state = Up, LID = Serial0/4/7.1


Router#show xconnect all
Legend:    XC ST=Xconnect State  S1=Segment1 State  S2=Segment2 State
  UP=Up       DN=Down            AD=Admin Down      IA=Inactive
  SB=Standby  HS=Hot Standby     RV=Recovering      NH=No Hardware

XC ST  Segment 1                         S1 Segment 2                          S2
------+--------------------------------+--+--------------------------------+--
UP pri   ac MF5.100:100(FR DLCI)         UP mpls 3.3.3.3:100             UP
```

Multilink Frame Relay Layer 3 Termination

Table 37: Feature History

Feature Name	Release Information	Description
Multilink Frame Relay (MFR) Layer 3 Termination	Cisco IOS XE Dublin 17.11.1	You can configure Layer 3 termination using IPv4 and IPv6 addressing on the MFR sub interfaces for the following interface modules: • A900-IMA3G-IMSG and A900-IMA1Z8S-CXMS You can assign IP address on the MFR sub interface and terminate the Layer 3 traffic where ever required in the network.

On the RSP3 module, you can configure MFR interface on the following modes for the A900-IMA3G-IMSG interface module:

- Electrical T1/E1
- Electrical T3/E3

- For Optical OCx/STM, mode—OCx-VT1.5, CT3, and AU4-VC11

On the RSP3 module, you can configure MFR interface on the following modes for the NCS4200-3GMS interface module:

- For Optical OCx/STM, mode—OCx-VT1.5, CT3, and AU4-VC11

Restrictions for MFR Layer 3 Termination

- QOS, fragmentation, and interleaving are not supported.
- Sub interface number and DLCI number should be same.
- OSPF and ISIS are only supported.
- On the RSP2 module, MFR IPv4 ping is not supported.

How to Configure MFR Layer 3 Termination

Configuring MFR Layer 3 Termination

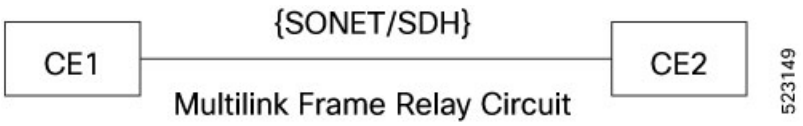
Scenario 1 - Configuring MFR Layer 3 Termination with IPv4 Address

Consider a scenario with the following configurations on CE1 and CE2. Both CE1 and CE2 are connected through serial interfaces and the traffic is carried through a multilink frame relay circuit.

CE1—On the serial interface 0/13/19.1 with frame relay as encapsulation, the default interface type as DTE, and default LMI type as Cisco, are configured. A sub interface MFR100.100 is created with DLCI as 100.

CE2—On the serial interface 0/13/19.1 with frame relay as encapsulation and interface type as DCE, a sub interface MFR100.100 is created with DLCI as 100.

Figure 2: Configuring MFR Layer 3 Termination with IPv4 Address



Configuring an MFR Interface and Sub Interface on CE1

```
CE1(config)#interface Serial0/13/19.1
CE1(config-if)#no ip address
CE1(config-if)#encapsulation frame-relay MFR100
CE1(config-if)#end


CE1(config-if)#interface MFR100
CE1(config-if)#no ip address
CE1(config-if)#frame-relay lmi-type ansi
CE1(config-if)#frame-relay intf-type dte
CE1(config-if)#end


CE1(config-if)#interface MFR100.100 point-to-point
```

```
CE1(config-subif)#ip address 192.10.2.1 255.255.255.0
CE1(config-subif)#frame-relay interface-dlci 100
CE1(config-fr-dlci)#end
```

Configuring an MFR Interface and Sub Interface on CE2

```
CE2(config)#interface Serial0/13/19.1
CE2(config-if)#no ip address
CE2(config-if)#encapsulation frame-relay MFR100
CE2(config-if)#end

CE2(config-if)#interface MFR100
CE2(config-if)#no ip address
CE2(config-if)#frame-relay lmi-type ansi
CE2(config-if)#frame-relay intf-type dce
CE2(config-if)#end

CE2(config-if)#interface MFR100.100 point-to-point
CE2(config-subif)#ip address 192.10.2.2 255.255.255.0
CE2(config-subif)#frame-relay interface-dlci 100
CE2(config-fr-dlci)#end
```

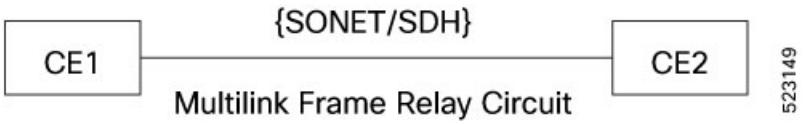
Scenario 2 - Configuring MFR Layer 3 Termination with IPv6 Address

Consider a scenario with the following configurations on CE1 and CE2. Both CE1 and CE2 are connected through serial interfaces and the traffic is carried through a multilink frame relay circuit.

CE1—An MFR interface MFR 100 is created with the interface type as DTE, and the default LMI type as ANSI. A sub interface MFR100.100 is created with DLCI as 100 and an IPv6 address as 2001:DB8:1::1.

CE2—An MFR interface MFR 100 is created with the interface type as DCE, and the default LMI type as ANSI. A sub interface MFR100.100 is created with DLCI as 100 and an IPv6 address as 2001:DB8:1::2.

Figure 3: Configuring MFR Layer 3 Termination with IPv6 Address



Configuring an MFR Interface and Sub Interface on CE1

```
CE1(config)#interface Serial0/13/19.1
CE1(config-if)#no ip address
CE1(config-if)#encapsulation frame-relay MFR100
CE1(config-if)#end

CE1(config-if)#interface MFR100
CE1(config-if)#no ip address
CE1(config-if)#frame-relay lmi-type ansi
CE1(config-if)#frame-relay intf-type dte
CE1(config-if)#end

CE1(config-if)#interface MFR100.100 point-to-point
CE1(config-subif)#ipv6 address 2001:10::1/64
CE1(config-subif)#ipv6 enable
CE1(config-subif)#frame-relay interface-dlci 100
CE1(config-fr-dlci)#end
```

```
CE1(config)#ipv6 unicast-routing
CE1(config)#end
```

Configuring an MFR Interface and Sub Interface on CE2

```
CE2(config)#interface Serial0/14/19.1
CE2(config-if)#no ip address
CE2(config-if)#encapsulation frame-relay MFR100
CE2(config-if)#end

CE2(config-if)#interface MFR100
CE2(config-if)#no ip address
CE2(config-if)#frame-relay lmi-type ansi
CE2(config-if)#frame-relay intf-type dce
CE2(config-if)#end

CE2(config-if)#interface MFR100.100 point-to-point
CE2(config-subif)#ipv6 address 2001:10::2/64
CE2(config-subif)#ipv6 enable
CE2(config-subif)#frame-relay interface-dlci 100
CE2(config-fr-dlci)#end

CE2(config)#ipv6 unicast-routing
CE2(config)#end
```

Verifying MFR Layer 3 Termination

Use the following **show** commands to verify the MFR Layer 3 termination:

- **show interface serial**
- **show ip interface brief**
- **show interfaces MFR1**
- **show frame-relay multilink MFR1**

```
CE1#show interfaces MFR1
MFR1 is up, line protocol is up
  Hardware is Multilink Frame Relay bundle interface
  MTU 1500 bytes, BW 18432 Kbit/sec, DLY 20000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation FRAME-RELAY, loopback not set
  Keepalive set (10 sec)
  DTR is pulsed for 2 seconds on reset
  LMI enq sent  0, LMI stat recvd 0, LMI upd recvd 0
  LMI enq recvd 4330, LMI stat sent  4330, LMI upd sent  0, DCE LMI up
  LMI DLCI 1023  LMI type is CISCO  frame relay DCE
  Broadcast queue 0/64, broadcasts sent/dropped 0/0, interface broadcasts 0
  Last input 00:00:06, output never, output hang never
  Last clearing of "show interface" counters 12:03:41
  Input queue: 0/375/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: fifo
  Output queue: 0/120 (size/max)
  5 minute input rate 0 bits/sec, 0 packets/sec
  5 minute output rate 0 bits/sec, 0 packets/sec
     108300 packets input, 1330362 bytes, 0 no buffer
     Received 0 broadcasts (0 IP multicasts)
     0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     108334 packets output, 1340642 bytes, 0 underruns
```

```
     Output 0 broadcasts (0 IP multicasts)
     0 output errors, 0 collisions, 0 interface resets
     0 unknown protocol drops
     0 output buffer failures, 0 output buffers swapped out
     0 carrier transitions

CE1#show frame-relay multilink MFR1
Bundle: MFR1, State = up, class = A, fragmentation disabled
 BID = MFR1
 Bundle links:
  Serial0/4/7.12, HW state = up, link state = Up, LID = Serial0/4/7.12
  Serial0/4/7.11, HW state = up, link state = Up, LID = Serial0/4/7.11
  Serial0/4/7.10, HW state = up, link state = Up, LID = Serial0/4/7.10
  Serial0/4/7.9, HW state = up, link state = Up, LID = Serial0/4/7.9
  Serial0/4/7.8, HW state = up, link state = Up, LID = Serial0/4/7.8
  Serial0/4/7.7, HW state = up, link state = Up, LID = Serial0/4/7.7
  Serial0/4/7.6, HW state = up, link state = Up, LID = Serial0/4/7.6
  Serial0/4/7.5, HW state = up, link state = Up, LID = Serial0/4/7.5
  Serial0/4/7.4, HW state = up, link state = Up, LID = Serial0/4/7.4
  Serial0/4/7.3, HW state = up, link state = Up, LID = Serial0/4/7.3
  Serial0/4/7.2, HW state = up, link state = Up, LID = Serial0/4/7.2
  Serial0/4/7.1, HW state = up, link state = Up, LID = Serial0/4/7.1
```

Multilink Frame Relay End-to-End Mode

Table 38: Feature History

Feature Name	Release Information	Description
Multilink Frame Relay (MFR) End-to-End Mode	Cisco IOS XE 17.13.1	This feature enables transporting legacy MFR traffic over packet switching core. You can now configure an end-to-end mode for frame relay pseudowire on the MFR interfaces for the following interface modules: • A900-IMA3G-IMSG • A900-IMA1Z8S-CXMS

Multilink Frame Relay (MFR) is a packet transport protocol based on the adoption of the Frame Relay Forum's End-to-End MFR (FRF.15) and UNI/NNI MFR (FRF.16) Implementation Agreements. It provides physical interface emulation for frame relay devices by aggregating multiple physical circuits to transport data. However, the aggregation of physical circuits appears as one logical data pipe.

For more information on MFR, see Multilink Frame Relay, on page 209.

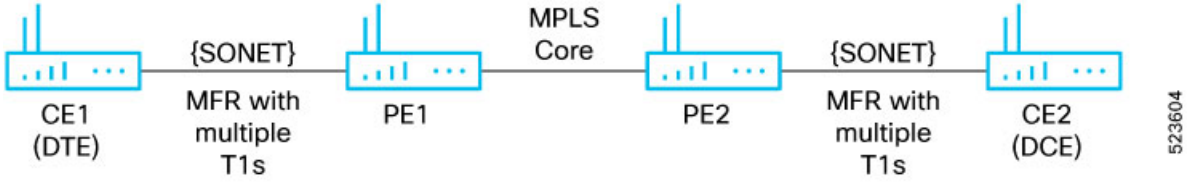
The MFR end-to-end mode feature specifies a method to aggregate multiple T1s into multiple FR bundles and to carry these bundles over an MPLS network. You can configure MFR end-to-end mode on SONET VT1.5 and CT-3 multiplexing modes for FR pseudowire.

How to Configure MFR End-to-End

The following section details how to configure MFR end-to-end.

Configuring MFR End-to-End

Consider a scenario where PE1 and PE2 are connected over MPLS core. CE1 is connected to PE1 and CE2 is connected to PE2.



CE1 Configuration

Follow the steps to configure CE1:

1. Configure MFR Interface.
2. Configure DLCI on Member Serial Interface.

MFR Interface Configuration

```
interface MFR20
 ip address 192.0.2.1 255.255.255.0
 frame-relay end-to-end
 frame-relay map ip 192.0.2.2 100
```

Note MFR ID should be the same for PE1 and CE1.

DLCI Configuration

```
interface Serial0/3/16.1
 no ip address
 encapsulation frame-relay MFR20
 frame-relay interface-dlci 101

interface Serial0/3/16.2
 no ip address
 encapsulation frame-relay MFR20
 frame-relay interface-dlci 102
```

PE1 Configuration

Follow the steps to configure PE1:

1. Configure MFR interface.
2. Configure DLCI on mMember serial interface.
3. Configure xconnect on MFR interface.

MFR Interface Configuration

```
interface MFR20
 no ip address
```

```
 frame-relay end-to-end
 frame-relay intf-type dce
```

DLCI Configuration

```
interface Serial0/7/0.1
 no ip address
 encapsulation frame-relay MFR20
 frame-relay interface-dlci 101

interface Serial0/7/0.2
 no ip address
 encapsulation frame-relay MFR20
 frame-relay interface-dlci 102
```

XConnect Configuration

```
pseudowire-class MFR_E2E
 encapsulation mpls
 interworking ip
 no control-word
 status
 status control-plane route-watch
 switching tlv


connect mfre2e MFR20 100 l2transport
 xconnect 198.51.100.1 200 encapsulation mpls pw-class MFR_E2E
```

Verify PE1 Configuration

```
PE1#show run | sec MFR_E2E
pseudowire-class MFR_E2E
 encapsulation mpls
 interworking ip
 no control-word
 status
 status control-plane route-watch
 switching tlv


PE1#sh run | sec connect
connect mfre2e MFR20 100 l2transport
 xconnect 203.0.113.1 200 encapsulation mpls pw-class MFR_E2E
```

PE2 Configuration

Follow the steps to configure PE2:

1. Configure MFR Interface.
2. Configure DLCI on member serial interface.
3. Configure xconnect on MFR interface.

MFR Interface Configuration

```
interface MFR30
 no ip address
 frame-relay end-to-end
 frame-relay intf-type dce
```

DLCI Configuration

```
interface Serial0/7/0.1
 no ip address
 encapsulation frame-relay MFR30
 frame-relay interface-dlci 101


interface Serial0/7/0.2
 no ip address
 encapsulation frame-relay MFR30
 frame-relay interface-dlci 102
```



Note MFR ID should be the same for PE2 and CE2.

XConnect Configuration

```
pseudowire-class MFR_E2E
 encapsulation mpls
 interworking ip
 no control-word
 status
 status control-plane route-watch
 switching tlv


connect mfre2e MFR30 100 l2transport
 xconnect 203.0.113.1 200 encapsulation mpls pw-class MFR_E2E
```

Verify PE2 Configuration

```
PE2#sh run | sec MFR_E2E
pseudowire-class MFR_E2E
 encapsulation mpls
 interworking ip
 no control-word
 status
 status control-plane route-watch
 switching tlv


PE2#sh run | sec connect
connect mfre2e MFR30 100 l2transport
 xconnect 203.0.113.1 200 encapsulation mpls pw-class MFR_E2E
```

CE2

Follow the steps to configure CE2:

1. Configure MFR interface.
2. Configure DLCI on member serial interface.

MFR Interface Configuration

```
interface MFR30
 ip address 192.0.2.2 255.255.255.0
 frame-relay end-to-end
 frame-relay map ip 192.0.2.1 100
```

DLCI Configuration

```
interface Serial0/3/16.1
 no ip address
 encapsulation frame-relay MFR30
 frame-relay interface-dlci 101


interface Serial0/3/16.2
 no ip address
 encapsulation frame-relay MFR30
 frame-relay interface-dlci 102
```

Verifying MFR End-to-End

Use the following **show** commands to verify the MFR end-to-end configuration:

- **show interface *interface-name***
- **show xconnect all**
- **show mpls l2transport vc 200 detail | in MPLS**

You can verify details about the MFR interface and traffic using the **show interface *interface-name***.

```
PE1#show interface MFR20
MFR20 is up, line protocol is up
  Hardware is Multilink Frame Relay bundle interface
  MTU 1500 bytes, BW 21504 Kbit/sec, DLY 20000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation FRAME-RELAY, loopback not set
  Keepalive set (10 sec)
  DTR is pulsed for 2 seconds on reset
  LMI enq sent  0, LMI stat recvd 0, LMI upd recvd 0
  LMI enq recvd 1719, LMI stat sent  1719, LMI upd sent  0, DCE LMI up
  LMI DLCI 1023  LMI type is CISCO  frame relay DCE
  Broadcast queue 0/64, broadcasts sent/dropped 0/0, interface broadcasts 0
  Last input 00:00:04, output never, output hang never
  Last clearing of "show interface" counters 04:50:59
  Input queue: 0/375/0/0 (size/max/drops/flushes); Total output drops: 1
  Queueing strategy: fifo
  Output queue: 0/120 (size/max)
5 minute input rate 9000 bits/sec, 9 packets/sec
     5 minute output rate 9000 bits/sec, 9 packets/sec
        102901 packets input, 11762696 bytes, 0 no buffer
     Received 0 broadcasts (0 IP multicasts)
     0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
     102587 packets output, 11726574 bytes, 0 underruns
     Output 0 broadcasts (0 IP multicasts)
     0 output errors, 0 collisions, 0 interface resets
     0 unknown protocol drops
     0 output buffer failures, 0 output buffers swapped out
     0 carrier transitions
```

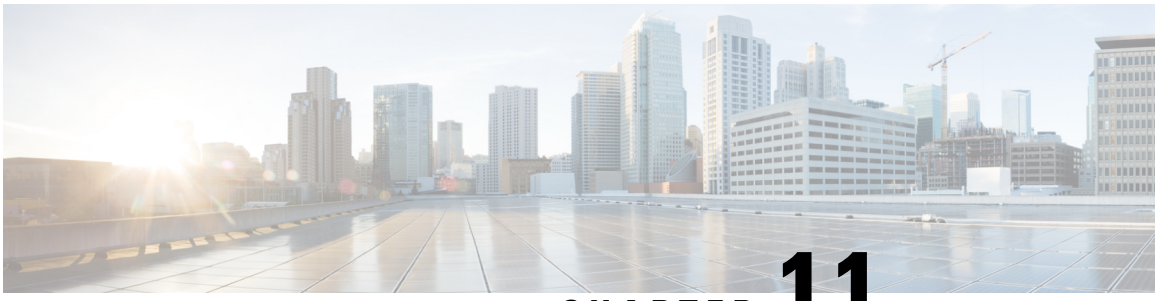
You can verify the MFR xconnect circuit status using the **show xconnect all**.

```
PE1#show xconnect all
Legend:    XC ST=Xconnect State  S1=Segment1 State  S2=Segment2 State
  UP=Up       DN=Down            AD=Admin Down      IA=Inactive
  SB=Standby  HS=Hot Standby     RV=Recovering      NH=No Hardware
XC ST  Segment 1                         S1 Segment 2                         S2
```

```
------+---------------------------------+--+---------------------------------+--
UP pri   ac MF20:100(FR DLCI)            UP mpls 3.3.3.3:200                  UP
```

You can verify and check the MPLS virtual circuit label information using the **show mpls l2transport vc 200 detail | in MPLS** command.

```
PE1#show mpls l2transport vc 200 detail | in MPLS
    MPLS VC labels: local 17, remote 17
```



CHAPTER 11

QoS on Layer 3 Terminated MLPPP Interfaces

Table 39: Feature History

Feature Name	Release Information	Description
QoS on Layer 3-terminated MLPPP Interface	Cisco IOS XE Dublin 17.10.1	You can configure QoS features such as classification, shaping, queuing, bandwidth, and weighted random early detection on the layer 3-terminated MLPPP interfaces at the egress direction for the following interface modules: • 1 port OC-48/STM-16 or 4 port OC-12/OC-3 / STM-1/STM-4 + 12 port T1/E1 + 4 port T3/E3 CEM Interface Module (A900-IMA3G-IMSG) • 1-Port OC-192 or 8-Port Low Rate CEM 20G Bandwidth Interface Module (A900-IMA1Z8S-CXMS)

Starting with the Cisco IOS XE Dublin 17.10.1 release, you can configure the following QoS features on the Layer 3-terminated MLPPP interface on the SONET or SDH controller for the Cisco RSP3 module.

- **Egress Classification**—Classification based on the QoS group.
- **Egress Shaping**—Shaping at the egress direction only based on the class QoS group. The shaping average range is from 384 Kbps to 100 Gbps.
- **Egress Queuing**—Supports egress class-based weighted fair queuing (CBWFQ) and egress Low-Latency queuing (LLQ) with two-level priority and shaping.
- **Egress Bandwidth**—Supports bandwidth (in kbps), bandwidth remaining ratio (BRR), and bandwidth remaining percent (BRP).
    - You can configure bandwidth committed information rate (CIR) from 100 Kbps to 10 Gbps.

- If the **priority** command is configured, then you can configure the **bandwidth remaining** only for the other classes.
- The BRR ratio that you can configure is 1–63 (1-4096).

- **Egress Weighted Random Early Detection (WRED)**
  - WRED is based on the discard-class only.
  - The class-map match condition is based on the QoS group whereas the WRED is based on the discard class.
  - The queuing features such as shape or bandwidth supportsWRED in a class.
  - Supports minimum and maximum thresholds (bytes or microseconds only).
  - The two WRED profiles that are supported per class are DC0 and DC1.

- Queue limit (in bytes and usec).

For more information on QoS, refer the Quality of Service Configuration Guidelines for RSP3 Module.

- Restrictions For Layer 3 Terminated MLPPP Interface, on page 226
- How to Configure QoS on Layer 3 Terminated MLPPP Interface, on page 226
- Configuring Shaping, on page 228
- Configuring Bandwidth, on page 228
- Configuring Bandwidth Remaining Percent, on page 228
- Configuring Bandwidth Remaining Ratio, on page 228
- Configuring Priority, on page 229
- Configuring WRED, on page 229
- Verifying QoS Configuration on Layer 3 Terminated MLPPP Interface, on page 229

Restrictions For Layer 3 Terminated MLPPP Interface

- QoS in ingress is not supported.
- Different bandwidth ranges cannot be combined in the same policy. You cannot configure BRR in one class and BRP in another class for the same policy.
- When configuring BRR or BRP, 15% of the total bandwidth should be allocated to the class-default.
- For policy without any queuing actions (for example, classification), you should remove the policy first before changing members in a multilink interface to a different interface module.

How to Configure QoS on Layer 3 Terminated MLPPP Interface

Configuring Classification

Configuring Class Map

The following is a sample configuration to create class map that matches any of the listed criteria.

```
class-map match-any qos-group0
 match qos-group 0
class-map match-any qos-group1
 match qos-group 1
class-map match-any qos-group2
 match qos-group 2
class-map match-any qos-group3
 match qos-group 3
class-map match-any qos-group4
 match qos-group 4
class-map match-any qos-group5
 match qos-group 5
class-map match-any qos-group6
 match qos-group 6
class-map match-any qos-group7
 match qos-group 7
```

Enabling SDM Template

Enter the following command to enable the **egr_l3vpn_cm** SDM template:

```
Router(config)# sdm prefer enable_egr_l3vpn_cm
```



Note Starting with Cisco IOS XE 17.14.1 release, you must enable the **egr_l3vpn_cm** template before attaching a policy map to an interface.

For the SDM template to take effect, restart the router.

Configuring Policy Map

The following is a sample configuration to create a policy map for Layer 3 egress QoS group that specifies several classes.

```
policy-map l3egressqos-groupbrp
 class qos-group0
 class qos-group1
 class qos-group2
 class qos-group3
 class qos-group4
 class qos-group5
 class qos-group6
 class qos-group7
```

You can apply the policy map on the MLPPP interface.

```
router#configure terminal
router(config)#interface Serial0/7/19.1
router(config-if)#service-policy output l3egressqos-groupbrp
router(config-if)#end
```

Configuring Shaping

The following is a sample configuration for a Layer 3 egress QoS group for a policy map having class QoS groups 0, 1, and 2 configured with shape average.

```
policy-map l3egressqos-groupbrp
class qos-group0
             shape average 384000
class qos-group1
             shape average 384000
class qos-group2
             shape average 384000
```

Configuring Bandwidth

The following is a sample configuration for a Layer 3 egress QoS group for a policy map having class QoS groups 0, 1, and 2 configured with various bandwidth percent.

```
policy-map l3egressqos-groupbrp
class qos-group0
             bandwidth percent 10
class qos-group1
             bandwidth percent 10
class qos-group2
             bandwidth percent 20
```

Configuring Bandwidth Remaining Percent

The following is a sample configuration for a Layer 3 egress QoS group for a policy map having class QoS groups 0, 1, and 2 configured with various bandwidth remaining percent.

```
policy-map l3egressqos-groupbrp
class qos-group0
             bandwidth remaining percent 10
class qos-group1
             bandwidth remaining percent 20
class qos-group2
             bandwidth remaining percent 30
```

Configuring Bandwidth Remaining Ratio

The following is a sample configuration for a Layer 3 egress QoS group for a policy map having class QoS groups 0, 1, and 2 configured with various bandwidth remaining ratio.

```
policy-map l3egressqos-groupbrp
class qos-group0
             bandwidth remaining ratio 10
class qos-group1
             bandwidth remaining ratio 20
```

```
class qos-group2
            bandwidth remaining ratio 30
```

Configuring Priority

The following is a sample configuration for a Layer 3 egress QoS group for a policy map having class QoS groups 0 configured with shape priority percent.

```
policy-map l3egressqos-groupbrp
class qos-group0
            priority Percent 20
policy-map l3egressqos-groupbrp
class qos-group0
            priority percent 40
```

Configuring WRED

```
class-map match-all qos1
 match qos-group 1
policy-map egress
  class qos1
  shape average 100000000
  queue-limit 300 us
  random-detect discard-class-based
  random-detect discard-class 0 100 us 200 us 100
  random-detect discard-class 1 200 us 300 us 100
```

Verifying QoS Configuration on Layer 3 Terminated MLPPP Interface

The following **show policy-map** command for egress QoS shows bandwidth that is configured for each QoS group.

```
router#show policy-map
  Policy Map l3egressqos-groupbrp
    Class qos-group0
      bandwidth 10 (%)
    Class qos-group1
      bandwidth 10 (%)
    Class qos-group2
      bandwidth 10 (%)
    Class qos-group3
      bandwidth 10 (%)
    Class qos-group4
      bandwidth 10 (%)
    Class qos-group5
      bandwidth 10 (%)
    Class qos-group6
      bandwidth 10 (%)
    Class qos-group7
      bandwidth 10 (%)
```

The following **show policy-map interfac** command shows the policy map statistics on the MLPPP interface.

```
router#show policy-map interface Multilink 1
 Serial0/7/19.1
  Service-policy output: l3egressqos-groupbrp
    Class-map: qos-group0 (match-any)
      1135 packets, 1135000 bytes
      30 second offered rate 303000 bps
      Match: qos-group 0
    Class-map: qos-group1 (match-any)
      1135 packets, 1135000 bytes
      30 second offered rate 303000 bps
      Match: qos-group 1
    Class-map: qos-group2 (match-any)
      1135 packets, 1135000 bytes
      30 second offered rate 303000 bps
      Match: qos-group 2
    Class-map: qos-group3 (match-any)
      1135 packets, 1135000 bytes
      30 second offered rate 303000 bps
      Match: qos-group 3
Class-map: qos-group4 (match-any)
      1135 packets, 1135000 bytes
      30 second offered rate 303000 bps
      Match: qos-group 4
    Class-map: qos-group5 (match-any)
      1135 packets, 1135000 bytes
      30 second offered rate 303000 bps
      Match: qos-group 5
    Class-map: qos-group6 (match-any)
      1135 packets, 1135000 bytes
      30 second offered rate 303000 bps
      Match: qos-group 6
    Class-map: qos-group7 (match-any)
      1135 packets, 1135000 bytes
      30 second offered rate 303000 bps
      Match: qos-group 7
    Class-map: class-default (match-any)
      0 packets, 0 bytes
      30 second offered rate 0000 bps, drop rate 0000 bps
      Match: any
```

The following **show platform hardware** command details the egress QoS resource details for debugging purposes.

```
router#show platform hardware pp active feature qos resource-summary 0
RSP3 QoS Resource Summary
Type                                      Total       Used        Free
------------------------------------------------------------------------------
QoS TCAM                                  2048         0          2048
VOQs                                      49152       784         48368
QoS Policers                              32768        0          32768
QoS Policer Profiles                      1023         0          1023
Ingress CoS Marking Profiles              16           1          15
Egress CoS Marking Profiles               16           1          15
Ingress Exp & QoS-Group Marking Profiles  64           3          61
Ingress QOS LPM Entries                   32768        0          32768

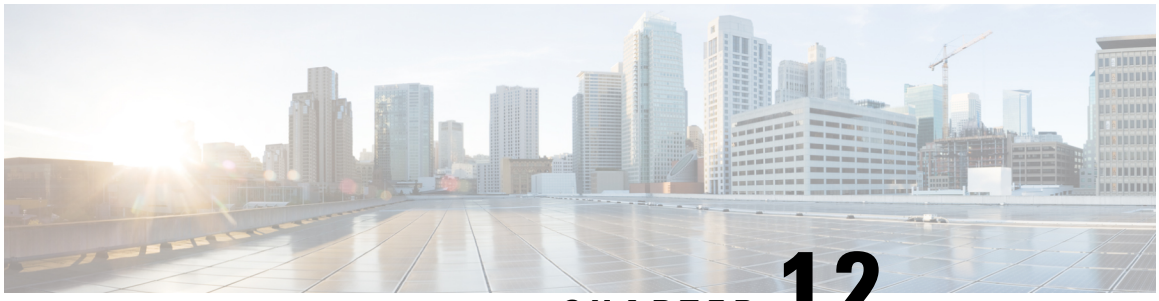
router#show platform hardware pp active feature qos resource-summary 1
RSP3 QoS Resource Summary
Type                                      Total       Used        Free
------------------------------------------------------------------------------
QoS TCAM                                  2048         0          2048
```

```
VOQs                                    49152       784         48368
QoS Policers                            32768        0          32768
QoS Policer Profiles                    1023         0          1023
Ingress CoS Marking Profiles            16           1          15
Egress CoS Marking Profiles             16           1          15
Ingress Exp & QoS-Group Marking Profiles  64           3          61
Ingress QOS LPM Entries                 32768        0          32768

router#show platform ha pp active bshell "diag cosq voq con=1"

Ingress VOQs Sizes (format: [queue_id(queue_size)]):
[8504(1032192B)]        [8505(1032192B)]        [8506(1032192B)]        [8507(1031168B)]
[8508(1032192B)]        [8509(1032192B)]        [8510(1032192B)]        [8511(1032192B)]

router#show platform ha pp active bshell "diag count voq voq queue=8504"
voq[8504] num_cosq[1 ]
        voq max occupancy0 level: 12, refresh: true
        voq enqueue packet: 240[]
        voq dequeue packet: 1358182[]
        voq total discarded packet: 3315[]
        voq deleted packet: 0[]
```



CHAPTER 12

VLAN Handoff

Table 40: Feature History

Feature Name	Release	Description
CEM and IP IW Feature Parity for A900-IMA1Z8S-CXMS and A900-IMA3G-IMSG Interface Modules	Cisco IOS XE Bengaluru 17.4.1	Support for IPv4 and IPv6 with VLAN handoff for both cross connect and local connect on A900-IMA1Z8S-CXMS and A900-IMA3G-IMSG Interface Module.
IP Interworking with VLAN Handoff	Cisco IOS XE Amsterdam 17.3.1	VLAN handoff enables the support for IP interworking Pseudowire. IP interworking Pseudowire enables the service provider to terminate the TDM circuit early in the network and transport the IP payload on HDLC, PPP, or MLPPP links, over the MPLS core to the Ethernet network.

This module describes the configuration of the VLAN handoff, which is an extension of the IP interworking pseudowire. The VLAN handoff enables the support for IP interworking pseudowire between HDLC, PPP, or MLPPP channel links to Ethernet virtual circuits (EVC).

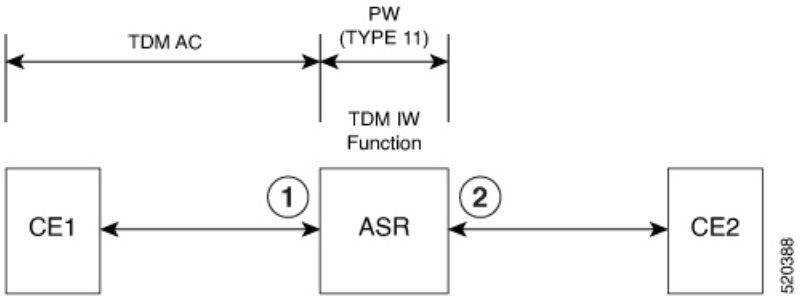
- Overview of VLAN Handoff, on page 233
- IP Interworking Switching on Single Router, on page 234
- Restrictions for VLAN Handoff, on page 234
- Enabling the VLAN Handoff, on page 234
- Configuring VLAN Handoff for IPv4 Local Connect, on page 235
- Configuring VLAN Handoff for IPv4 Cross Connect, on page 237
- Configuring VLAN Handoff for IPv6 Local Connect, on page 239
- Configuring VLAN Handoff for IPv6 Cross Connect, on page 241

Overview of VLAN Handoff

IP interworking pseudowire enables the service provider to terminate the TDM circuit early in the network and transport the IP payload on HDLC, PPP, or MLPPP links to the Ethernet network.

IP Interworking Switching on Single Router

Figure 4: Local Connect Setup



1	Terminate the circuit locally. IP keyword extracts the IP packets and transports it over PW and creates PW (Type 11)	2	IP PW (Type 11) terminated

Restrictions for VLAN Handoff

- Ingress logical interface range must be reserved, with not more than 4K EVCs that can be supported per ASIC. This reduces the EVC scale from 16K to 8K, with a maximum of 4K EVCs per ASIC.
- You can configure only a maximum of 3998 serial interface or Interworking Multiservice Gateway (iMSG).
- For a ping to work, resolve the ARP from the Ethernet interface.
- VLAN handoff with a local connect over HDLC, PPP, or MLPPP is not supported when configured with port channel.
- Only IPv4 is supported until Cisco IOS XE Amsterdam 17.3.1.

Enabling the VLAN Handoff

Use the **enable_tdm_to_ip_iw** command to enable the SDM template.

```
Router# config terminal
Router(config)# sdm prefer enable_tdm_to_ip_iw
```

Reload the router after you enable the template.

The new template is added and the ROMMON variable is set to 28.

```
TDM_TO_IP_FEAT_EXT_TEMPLATE = 28
```

Note You must reload the router for the new template to be effective.

Configuring VLAN Handoff for IPv4 Local Connect

Before you begin

Interface module must be free from all configurations.

Procedure

Step 1 Configure the serial or MLPPP interface on a customer edge (CE).

To configure the interface on CE1, enter the following commands:

```
controller SONET 4/0/0
framing sonet
clock source line
!
sts-1 1
mode vt-15
vtg 1 t1 1 channel-group 0 timeslots 1-24
```

Step 2 Configure the serial or MLPPP interface on a provide edge (PE).

To configure the interface on PE, enter the following commands:

```
controller SONET 0/4/17
framing sonet
clock source line
!
sts-1 1
mode vt-15
vtg 1 t1 1 channel-group 0 timeslots 1-24
```

Step 3 Configure service instance on the Ethernet interface.

To configure service instance on the Ethernet interface, enter the following commands:

```
interface TenGigabitEthernet0/1/1
no ip address

service instance 10 ethernet
encapsulation dot1q 10
rewrite ingress tag pop 1 symmetric
!
end
```

Note
Only single tag EPF is supported.

Step 4 Bind the service instance and the serial interface under L2VPN xconnect.

To create L2VPN for local connect and bind the service instance and serial interface, enter the following commands:

```
l2vpn xconnect context vlan_handoff_10
interworking ip
member Serial0/4/17.1
member TenGigabitEthernet0/1/1 service-instance 10
```

Step 5 Configure the service instance on CE2 to terminate the traffic on BDI or VLAN.

To configure the service instance, enter the following commands:

```
interface TenGigabitEthernet0/12/1
no ip address
service instance 10 ethernet
encapsulation dot1q 10
rewrite ingress tag pop 1 symmetric
bridge-domain 10
!
end
interface BDI10
ip address 10.12.12.2 255.0.0.0
no shut
```

Example - VLAN Handoff for IPv4 Local Connect

The following is a sample VLAN handoff configuration for CE and PE respectively.

```
Router# show running-config | sec 4/0/0
controller SONET 4/0/0
 framing sonet
 clock source line
 !
 sts-1 1
  mode vt-15
  vtg 1 t1 1 channel-group 0 timeslots 1-24

Router# show ip int brief | i Se
             Serial4/0/0.1/1/1:0    10.12.12.1      YES manual up                    up
```

```
Serial Interface Configuration
platform enable controller MediaType 0/4/17 oc12
controller MediaType 0/4/17
 mode sonet
controller SONET 0/4/17
 no snmp trap link-status
 rate OC12
 no ais-shut
 alarm-report all
 threshold sf-ber 3
 clock source internal
 !
 sts-1 1
  clock source internal
  mode vt-15
  vtg 1 t1 1 channel-group 0 timeslots 1-24
 !

Gigabit Ethernet Configuration
```

```
interface TenGigabitEthernet0/1/1
 no ip address
 service instance 10 ethernet
  encapsulation dot1q 10
  rewrite ingress tag pop 1 symmetric
 !
end

L2vpn xconnect
l2vpn xconnect context vlan_handoff_10
 interworking ip
 member Serial0/4/17.1
 member TenGigabitEthernet0/1/1 service-instance 10
```

Configuration on CE2

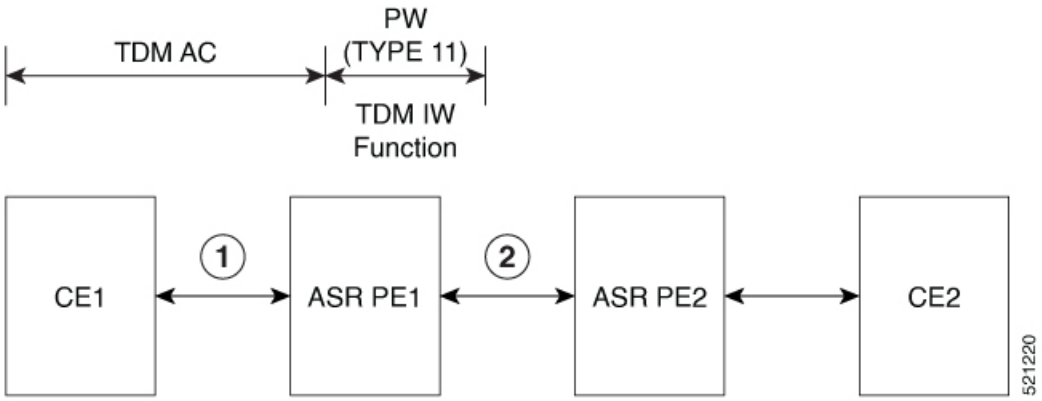
```
interface TenGigabitEthernet0/12/1
 no ip address
 service instance 10 ethernet
  encapsulation dot1q 10
  rewrite ingress tag pop 1 symmetric
  bridge-domain 10
 !
end

interface BDI10
ip address 10.12.12.2 255.0.0.0
no shut

Router# show ip int brief | i BDI
 BDI10                  10.12.12.2      YES manual up                    up
```

Configuring VLAN Handoff for IPv4 Cross Connect

Figure 5: Cross Connect Setup



Before you begin

Interface module must be free from all configurations.

Procedure

Step 1 Configure the serial interface on CE1.

To configure the serial interface on CE1, enter the following commands:

```
controller sonet 4/1/0
sts-1 1
mode vt-15
vtg 1 t1 1 channel-group 0 timeslots 1-24

interface Serial4/1/0.1/1/1:0
ip address 10.10.10.1 255.0.0.0
end
```

Step 2 Perform the following configurations on PE1:

a) To configure the serial interface on PE1, enter the following commands:

```
controller sonet 0/5/16
sts-1 1
mode vt-15
vtg 1 t1 1 channel-group 0 timeslots 1-24
```

b) To configure pseudowire on PE1, enter the following commands:

```
interface pseudowire100
encapsulation mpls
signaling protocol ldp
neighbor 10.2.2.2 100
```

c) To perform L2VPN cross-connect, enter the following commands:

```
l2vpn xconnect context vlan_handoff_xconn_100
interworking ip
member serial0/5/16.1
member pseudowire100
```

Note
Ensure that PE1 and PE2 are reachable through any routing protocol and LDP is up.

Step 3 Perform the following configurations on PE2:

a) To configure pseudowire on PE2, enter the following commands:

```
interface pseudowire100
encapsulation mpls
signaling protocol ldp
neighbor 10.1.1.1 100
```

b) To configure service instance on the Ethernet interface, enter the following commands:

```
interface tengig 0/12/1
no shut
interface tengig 0/12/1
service instance 100 ethernet
encapsulation dot1q 100
rewrite ingress tag pop 1 symmetric
```

c) To perform L2VPN cross-connect, enter the following commands:

```
l2vpn xconnect context vlan_handoff_xconn_100
interworking ip
member tengig0/12/1 service-instance 100
member pseudowire100
```

Step 4 Terminate the serial interface on the Ethernet interface.

Terminate the serial interface on the Ethernet interface, enter the following commands:

```
interface tengig 0/4/0
no shut

interface tengig 0/4/0
service instance 100 ethernet
encapsulation dot1q 100
rewrite ingress tag pop 1 symmetric
bridge-domain 100

interface BDI100
ip add 10.10.10.2 255.0.0.0
no shut
```

Configuring VLAN Handoff for IPv6 Local Connect

Table 41: Feature History

Before you begin

Interface module must be free from all configurations.

Procedure

Step 1 Configure the serial or MLPPP interface on a customer edge (CE).

To configure the interface on CE1, enter the following commands:

```
controller SONET 4/0/0
framing sonet
clock source line
!
sts-1 1
```

```
mode vt-15
vtg 1 t1 1 channel-group 0 timeslots 1-24

interface Serial4/0/0.1/1/1:0
ipv6 address 2001:1::1/64
ipv6 enable
end
```

Step 2 Configure the serial or MLPPP interface on a provide edge (PE).

To configure the interface on PE, enter the following commands:

```
controller SONET 0/4/17
framing sonet
clock source line
!
sts-1 1
mode vt-15
vtg 1 t1 1 channel-group 0 timeslots 1-24
```

Step 3 Configure service instance on the Ethernet interface.

To configure service instance on the Ethernet interface, enter the following commands:

```
interface TenGigabitEthernet0/1/1
no ip address

service instance 10 ethernet
encapsulation dot1q 10
rewrite ingress tag pop 1 symmetric
!
end
```

Note
Only single tag EPF is supported.

Step 4 Bind the service instance and the serial interface under L2VPN xconnect.

To create L2VPN for local connect and bind the service instance and serial interface, enter the following commands:

```
l2vpn xconnect context vlan_handoff_10
interworking ipv6
member Serial0/4/17.1
member TenGigabitEthernet0/1/1 service-instance 10
```

Step 5 Configure the service instance on CE2 to terminate the traffic on BDI or VLAN.

To configure the service instance, enter the following commands:

```
interface TenGigabitEthernet0/12/1
no ip address
service instance 10 ethernet
encapsulation dot1q 10
rewrite ingress tag pop 1 symmetric
bridge-domain 10
!
end
interface BDI10
ipv6 address 2001:1::2/64
```

```
ipv6 enable
no shut
```

Note

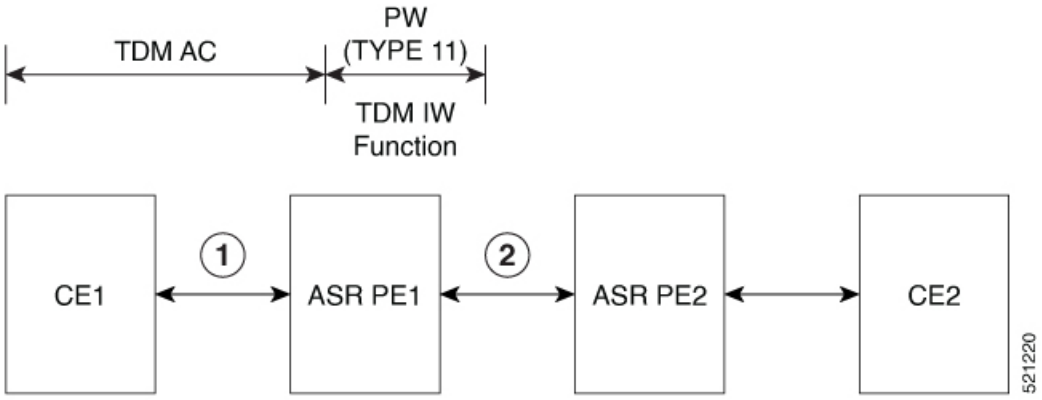
- Ensure that atleast one interface is enabled with IPv6 on the TDM routers, for example:

```
loopback 111
ipv6 enable
```

- IPv6 unicast routing has to be enabled on all the routers.

Configuring VLAN Handoff for IPv6 Cross Connect

Figure 6: Cross Connect Setup



Before you begin

Interface module must be free from all configurations.

Procedure

Step 1 Configure the serial interface on CE1.

To configure the serial interface on CE1, enter the following commands:

```
controller sonet 4/1/0
sts-1 1
mode vt-15
vtg 1 t1 1 channel-group 0 timeslots 1-24

interface Serial4/1/0.1/1/1:0
ipv6 address 2001:1::1/64
ipv6 enable
end
```

Step 2 Perform the following configurations on PE1:

a) To configure the serial interface on PE1, enter the following commands:

```
controller sonet 0/5/16
sts-1 1
mode vt-15
vtg 1 t1 1 channel-group 0 timeslots 1-24
```

b) To configure pseudowire on PE1, enter the following commands:

```
interface pseudowire100
encapsulation mpls
signaling protocol ldp
neighbor 10.2.2.2 100
```

c) To perform L2VPN cross-connect, enter the following commands:

```
l2vpn xconnect context vlan_handoff_xconn_100
interworking ip
member serial0/5/16.1
member pseudowire100
```

Note
Ensure that PE1 and PE2 are reachable through any routing protocol and LDP is up.

Step 3 Perform the following configurations on PE2:

a) To configure pseudowire on PE2, enter the following commands:

```
interface pseudowire100
encapsulation mpls
signaling protocol ldp
neighbor 10.1.1.1 100
```

b) To configure service instance on the Ethernet interface, enter the following commands:

```
interface tengig 0/12/1
no shut
interface tengig 0/12/1
service instance 100 ethernet
encapsulation dot1q 100
rewrite ingress tag pop 1 symmetric
```

c) To perform L2VPN cross-connect, enter the following commands:

```
l2vpn xconnect context vlan_handoff_xconn_100
interworking ipv6
member tengig0/12/1 service-instance 100
member pseudowire100
```

Step 4 Terminate the serial interface on the Ethernet interface.

To terminate the serial interface on the Ethernet interface, enter the following commands:

```
interface tengig 0/4/0
no shut

interface tengig 0/4/0
service instance 100 ethernet
encapsulation dot1q 100
rewrite ingress tag pop 1 symmetric
bridge-domain 100

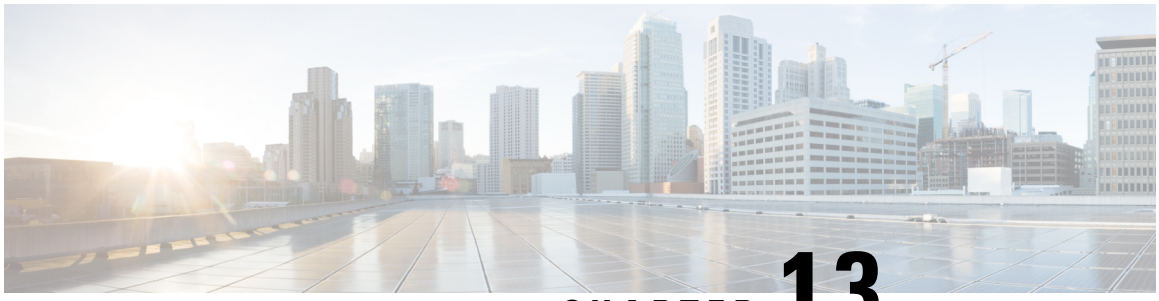
interface BDI100
ipv6 address 2001:1::1/64
ipv6 enable
no shut
```



PART IV

OCx Protection

- Automatic Protection Switching , on page 247
- Configuring MSP, on page 265
- UPSR Path Protection, on page 277
- Unidirectional Path Switching Ring Over HDLC, on page 281
- Configuring SNCP, on page 289



CHAPTER 13

Automatic Protection Switching

Table 42: Feature History

Feature Name	Release Information	Feature Description
IMA3G 1+1 OC3/12 Single Card APS Support	Cisco IOS XE Amsterdam 17.3.1	Automatic protection switching (APS) is a protection mechanism for SONET networks that enables SONET connections to switch to another SONET circuit when a circuit failure occurs. This protection schemes allows a pair of SONET lines or paths to be configured for line or path redundancy. In the event of a fiber cut, the active line or path switches automatically to the standby line or path. In the 1+1 architecture, there is one working interface (circuit) and one protection interface, and the same payload from the transmitting end is sent to both the receiving ends. The receiving end decides which interface to use.
CEM and IP IW Feature Parity for A900-IMA1Z8S-CXMS and A900-IMA3G-IMSG Interface Modules	Cisco IOS XE Bengaluru 17.4.1	Support for APS and non-APS on SDH and SONET for iMSG IPv6 interworking on A900-IMA1Z8S-CXMS and A900-IMA3G-IMSG Interface Module.

Automatic protection switching (APS) is a protection mechanism for SONET networks that enables SONET connections to switch to another SONET circuit when a circuit failure occurs. A protection interface serves as the backup interface for the working interface. When the working interface fails, the protection interface quickly assumes its traffic load.

The SONET protection schemes partially comply with Telcordia—GR-253-CORE standard. It allows Optical Interface Module to work seamlessly as SONET Add or Drop Multiplexers (ADMs). The implementation of

the above protection schemes allows a pair of SONET lines or paths to be configured for line or path redundancy. In the event of a fiber cut, the active line or path switches automatically to the standby line or path in up to 60 milliseconds (2/5/10 millisecond for holdover and 50 millisecond switchovers).

Optical Interface Module supports the following SONET protection switching schemes:

- Linear Bidirectional 1+1 APS
- Linear Unidirectional 1+1 APS
- UPSR Path Protection at STS Level
- UPSR Path Protection at VT Level

- 1+1 APS, on page 248
- Restrictions for APS, on page 250
- Configuring CEM APS for Framed SAToP, on page 250
- Provisioning APS 1+1, on page 252
- Deprovisioning APS 1+1, on page 252
- Configuring APS for SAToP, on page 253
- Monitoring Protection Switching Count for Protected SONET Interface, on page 258

1+1 APS

In the 1+1 architecture, there is one working interface (circuit) and one protection interface, and the same payload from the transmitting end is sent to both the receiving ends. The receiving end decides which interface to use. The line overhead (LOH) bytes (K1 and K2) in the SONET frame indicate both status and action.

The protection interfaces need to be configured with an IP address of the chassis that has the working interface, using APS commands. The APS Protect Group Protocol, which runs on top of UDP, provides communication between the process controlling the working interface and the process controlling the protection interface. Using this protocol, interfaces can be switched because of a chassis failure, degradation or loss of channel signal, or manual intervention. In bidirectional mode, the receive and transmit channels are switched as a pair.

Two SONET connections are required to support APS.

The following option is available for linear bidirectional 1+1 APS:

- Revertive option — For any failure on working line, the software switches to protection line and when the working line recovers, it waits based on the revertive timer and reverts back to working line as active link.
- Non-revertive option — When the signal fails, the software switches to the protection line and does not automatically revert back to the working line. This is the default option.

The following features are supported on 1+1 APS:

- SONET PW (SAToP or CEP)
- SONET local connect

Benefits of APS

The following lists the benefits of APS:

- APS performs switchovers with minimal loss of data and time-consuming reroutes are avoided.
- There is no visibility that a failure has occurred beyond the network element in which it is residing; other nodes are not affected by the failure.
- Implementation of APS guards a network against complex restarts and resynchronizations since failures are isolated to a local device.
- With APS, the effect of a failure is greatly minimized and a fast switchover guarantees minimal effect on the network.

APS 1+1 for SONET Layer 1 traffic

SONET linear APS 1+1 provides protection against both fiber cuts and front card or back card failures. APS 1+1 requires a redundant protection line for every working line. The traffic is simultaneously carried by the working and the protection lines. Hence, the receiver that terminates the APS 1+1 should select the traffic from one of the lines and continue to forward the traffic. APS 1+1 provides protection in unidirectional and bi-directional modes:

- **Uni-directional Protection**: The receiving end can switch from working to protection line without any coordination at the transmit end since both lines transmit the same information.
- **Bi-directional Protection**: The receiving end switches from working to protection line by coordinating at the transmit end.

Scenario for Bidirectional APS 1+1

In the above figure, two are connected to provide APS 1+1 bi-directional protection. The highlighted one is the working line and the other is the protection line. The traffic is transmitted on both working and protection lines and received only on one line.

In a scenario where you encounter a fiber cut,

1. There is a cable cut in the working line. So, the receives a Loss of Signal (LOS) on working line.
2. starts generating K2 byte and sends it to the over the protection line.
3. receives the K2 byte and reacts on the receiving K2 byte.
4. starts sending K1 byte to the on the protection line.
5. starts sending K2 byte to on the protection line.
6. receives the K1/K2 byte and starts receiving the data from protection line. The protection line now acts as the active line.
7. sends K2 byte over the new active line to . receives this signal and starts accepting the data from this new active line.

Scenario for Unidirectional APS 1+1

In the above figure, two are connected to provide APS 1+1 unidirectional protection. The figure shows a working line and a protection line. The traffic is transmitted on both working and protection line and received only on one line.

In a scenario where you encounter a fiber cut,

1. receives a LOS on RX working line.
2. detects LOS and starts receiving the data from the protection line. The protection line now becomes the active line.
3. receives the K2 byte and knows about switching event on device 2.

Restrictions for APS

- APS group number of 255 and UPSR group ID of 1 can't be configured on the same router.
- For the releases earlier to Cisco IOS XE Cupertino 17.9.1, when there's a Line Remote Defect Indicator (LRDI) or Line Alarm Indication Signal (LAIS) alarm detected on the protect port, then the received K2 byte stays zero.

  For the releases later than Cisco IOS XE Cupertino 17.9.1, when there's an LRDI alarm on the protect channel, the received K2 reflects the LRDI alarm. Whereas for the LAIS alarm on the protect channel, due to all 1s in the SONET or SDH frame rx K1 or K2 becomes invalid, and the router displays the last received best value.
- The **aps exercise** command is not supported with A900-IMA1Z8S-CXMS and A900-IMA3G-IMSG interface modules.
- The APS switch commands are autocleared on reload and controller-shut operations.
- When APS is configured as the revertive mode, then **aps revert** must be enabled from both the ends.
- During *Wait-to-Restore (working)*, when you configure **no aps revert**, then it takes into effect only after the current wait to restore operation completes.
- On the RSP3 module, it takes a long time (for example, more than half an hour) to copy scale configuration (8064 VT CEP) from boot flash to the running configuration. As a workaround, you can copy the individual configuration one after the other from the CLI.
- You can perform a force switchover to overcome the following limitations:
  - An interface module OIR, either through physical or software causes the APS switchover time to be higher (500-600ms).
  - Shut or no shut of the port may lead to higher APS switchover time.
  - Removal of the active working or protect interface may lead to higher APS switchover time.

Configuring CEM APS for Framed SAToP

To configure unidirectional ACR (SONET Framing) for framed SAToP:

```
enable
configure terminal
controller sonet 0/4/16
rate OC3
clock source internal
aps group acr 1
aps working 1
```

```
exit
controller sonet 0/4/17
rate OC3
aps group acr 1
aps unidirectional
aps protect 1 10.7.7.7
aps revert 3
aps adm
controller sonet-acr 1
sts-1 1
mode vt-15
vtg 1 t1 1 cem-group 0 framed
end
```

To configure bi-directional ACR (SONET Framing) for Framed SAToP:

```
enable
configure terminal
controller sonet 0/4/16
rate OC3
clock source internal
aps group acr 1
aps working 1
exit
controller sonet 0/4/17
rate OC3
aps group acr 1
aps protect 1 10.7.7.7
controller sonet-acr 1
sts-1 1
mode vt-15
vtg 1 t1 1 cem-group 0 framed
end
```

Verifying SONET Configuration for Framed SAToP

To verify SONET configuration for Framed SAToP:

```
Router# show running configuration | sec 0/0/16
platform enable controller mediatype 0/0/16 oc3
controller mediatype 0/0/16
mode sonet
controller sonet 0/0/16
rate oc3
no ais-shut
alarm-report all
clock source internal
!
sts-1 1
clock source internal
mode vt-15
vtg 1 t1 1 cem-group 0 framed
!
sts-1 2
clock source internal
mode ct3
t3 framing c-bit
t3 clock source internal
t1 1 cem-group 1 framed
!
sts-1 3
clock source internal
```

```
mode ct3-e1
t3 framing c-bit
t3 clock source internal
e1 1 cem-group 2 framed
interface cem 0/0/16
no ip address
cem 0
!
cem 1
!
cem 2

#Router
```

Provisioning APS 1+1

Note Ensure to follow the steps only in the order provided.

Perform the following generic steps to provision APS 1+1.

Procedure

Step 1 Provision a physical controller with mode and rate.
Step 2 Put controllers into the APS group and define as working or protect.
Step 3 Setup STS1s on the sonet-acr controller. Cem-group placement is done on the logical port.
Step 4 Setup ACR or DCR clocking on the physical controllers.
Step 5 Provision clock recovered configuration under the recovered-clock section.
Step 6 Apply xconnect under the cem-acr interface.

Deprovisioning APS 1+1

Note Ensure to follow the steps only in the order provided.

Perform the following generic steps to deprovision APS 1+1.

Procedure

Step 1 Remove all xconnect under the cem-acr interface.
Step 2 Remove clock source for all ACR or DCR services under the physical controllers.

Step 3 Remove the clock recovered lines under the recovered-clock ACR section.

Step 4 Remove all provisioning under the sonet-acr controller. This step includes cem-group information and mode settings.

Step 5 Shut down the physical controller setup for Protect, remove APS provisioning, and apply no shut controller.

Step 6 Shut down the physical controller setup for Working, remove APS provisioning and apply no shut controller.

Step 7 Remove the *acr XX type* line in the configuration.

Step 8 Remove the mode SONET from each physical controller media type to restore the controller to its default setup.

Step 9 Remove ACR completely from the SONET or SDH interfaces. Ensure that you remove ACR from the virtual SONET and SDH controllers.

SONET Controller

```
config terminal
no controller sonet-acr <group-id>
end
```

The following example shows how to remove ACR completely from the SONET controller:

```
config terminal
no controller sonet-acr 100
end
```

SDH Controller

```
config terminal
no controller sdh-acr <group-id>
end
```

The following example shows how to remove ACR completely from the SDH controller:

```
config terminal
no controller sdh-acr 100
end
```

Configuring APS for SAToP

This section describes the configuration of APS for SAToP.

Configuring Bi-directional ACR (SONET Framing)

To configure bi-directional ACR (SONET Framing), use the following commands:

```
enable
configure terminal
controller sonet 0/0/16
clock source internal
aps group acr 1
aps working 1
exit
controller sonet 0/0/17
aps group acr 1
aps protect 1 10.7.7.7
end
```

Note To restore the system to its default condition, use the **no** form of the command.

Configuring Unidirectional APS

To configure unidirectional ACR (SONET Framing), use the following commands:

```
enable
configure terminal
controller sonet 0/0/16
clock source internal
aps group acr 1
aps working 1
aps unidirectional
exit
controller sonet 0/0/17
aps group acr 1
aps protect 1 10.7.7.7
aps revert 3
aps adm
end
```

Note To restore the system to its default condition, use the **no** form of the command.

Note Ensure that you use same interface modules for both work and protect links.

Verifying ACR Configurations

This section includes show commands for ACR: The following example shows the ACR groups that have been configured or deleted:

```
Router# show acr group

ACR Group Working I/f Protect I/f Currently Active Status

------------------------------------------------------------------------

1 SONET 0/0/16 SONET 0/0/16 SONET 0/0/16
```

The following example shows the configured working and protect CEM interfaces under the ACR controller:

```
Router# show acr group 1 detail cem
ACR Group      Working I/f     Protect I/f     Currently Active    Status
------------------------------------------------------------------------
CE1            CEM 0/0/16       CEM 0/0/17      CEM 0/0/16

CEM CKT Details
Cktid  State on Working    State on Protect
1         Enable Success      Enable Success
```

The following example shows the configuration under the ACR controller:

```
Router#show running-config | sec ACR
controller SONET-ACR 1
framing sonet
!
sts-1 1
  mode vt-15
  vtg 1 vt 1 cem-group 1 cep
!
sts-1 2
 !
sts-1 3
interface CEM-ACR1
no ip address
cem 1
!
```

The following example shows the loopback IP address for the router:

```
Router# show ip interface brief | i Loopback

Loopback0 172.16.0.1 YES NVRAM up up
```

The following example shows the CEM-ACR circuit status:

```
Router# show cem circuit

CEM Int. ID Ctrlr Admin Circuit AC
---------------------------------------------------------------
CEM-ACR1 1 UP UP Active UP
CEM-ACR1 2 UP UP Active UP
CEM-ACR1 3 UP UP Active UP
CEM-ACR1 4 UP UP Active UP
CEM-ACR1 5 UP UP Active UP
CEM-ACR1 6 UP UP Active UP
CEM-ACR1 7 UP UP Active UP
CEM-ACR1 8 UP UP Active UP
```

The following example shows the CEM-ACR circuit details for CEM group 0 under the CEM-ACR interface:

```
Router# #show cem circuit interface cem-acr 1 1

CEM-ACR1, ID: 0, Line: UP, Admin: UP, Ckt: ACTIVE
Path Mode : VT15, STS: 1, VTG: 1, T1: 1, CEM Mode: T1-SAToP
Controller state: up, T1/E1 state: up
Idle Pattern: 0xFF, Idle CAS: 0x8
Dejitter: 6 (In use: 0)
Payload Size: 192
Framing: Unframed
CEM Defects Set
None

Signalling: No CAS
RTP: Configured, RTP-HDR Compression: Disabled

Ingress Pkts:    8186065             Dropped:             0
Egress Pkts:     8186065             Dropped:             0

CEM Counter Details
Input Errors:    0                   Output Errors:       0
Pkts Missing:    0                   Pkts Reordered:      0
Misorder Drops:  0                   JitterBuf Underrun:  0
Error Sec:       0                   Severly Errored Sec: 0
Unavailable Sec: 0                   Failure Counts:      0
Pkts Malformed:  0                   JitterBuf Overrun:   0
Generated Lbits: 0                   Received Lbits:      0
```

```
Generated Rbits: 0                    Received Rbits:      0
```

The following example shows the MPLS L2 transport vc details for the specified vc. In this case it is the vc with vc-id = 1001:

```
Router# sh mpls l2 vc 1 det
Local interface: CE1 up, line protocol up, SATOP T1 1 up
  Destination address: 10.2.2.2, VC ID: 1, VC status: up
    Output interface: Te 0/0/16, imposed label stack {100}
    Preferred path: not configured
    Default path: active
    Next hop: 192.168.1.2
  Create time: 02:48:15, last status change time: 02:47:26
    Last label FSM state change time: 02:47:26
  Signaling protocol: LDP, peer 10.2.2.2:0 up
    Targeted Hello: 10.1.1.1(LDP Id) -> 10.2.2.2, LDP is UP
    Graceful restart: not configured and not enabled
    Non stop routing: configured and enabled
    Status TLV support (local/remote)   : enabled/supported
      LDP route watch                   : enabled
      Label/status state machine        : established, LruRru
      Last local dataplane   status rcvd: No fault
      Last BFD dataplane     status rcvd: Not sent
      Last BFD peer monitor  status rcvd: No fault
      Last local AC  circuit status rcvd: No fault
      Last local AC  circuit status sent: No fault
      Last local PW i/f circ status rcvd: No fault
      Last local LDP TLV     status sent: No status
      Last remote LDP TLV    status rcvd: No fault
      Last remote LDP ADJ    status rcvd: No fault
    MPLS VC labels: local 16, remote 100
    Group ID: local 38, remote 36
    MTU: local 0, remote 0
    Remote interface description:
  Sequencing: receive disabled, send disabled
  Control Word: On (configured: autosense)
  SSO Descriptor: 10.2.2.2/1, local label: 16
  Dataplane:
    SSM segment/switch IDs: 274581/4096 (used), PWID: 1
  VC statistics:
    transit packet totals: receive 0, send 0
    transit byte totals:   receive 0, send 0
    transit packet drops:  receive 0, seq error 0, send 0
```

The following example shows the currently configured APS groups on the router:

```
Router# show aps

SONET 0/0/16 APS Group 25: protect channel 0 (Inactive) (HA)
Working channel 1 at 10.1.1.1 (Enabled) (HA)
bidirectional, non-revertive
PGP timers (extended for HA): hello time=1; hold time=10
hello fail revert time=120
Received K1K2: 0x00 0x05
No Request (Null)
Transmitted K1K2: 0x00 0x00
No Request (Null)
Remote APS configuration: (null)
SONET 0/0/2 APS Group 25: working channel 1 (Active) (HA)
Protect at 10.1.1.1
PGP timers (from protect): hello time=1; hold time=10
Remote APS configuration: (null)
```

Configuring VT 1.5-T1 Loopback

To configure VT 1.5-T1 loopback, use the following commands:

```
enable
configure terminal
controller sonet 0/0/16
rate oc3
no ais shut
alarm- report all
framing sonet
clock source internal
sts-1 1
clock source internal
mode vt-15
vtg 1 t1 1 loopback local
end
```

Configuring VT 1.5-T1 BERT

To configure VT 1.5-T1 BERT, use the following commands:

```
enable
configure terminal
controller sonet 0/0/16
rate oc3
no ais shut
alarm- report all
framing sonet
clock source internal
sts-1 1
clock source internal
mode vt-15
vtg 1 t1 1 bert pattern 2^11 interval 10
end
```

Configuring Path Overhead

This section describes the configuration of path overhead.

C2 Flag

To configure the C2 flag, use the following commands:

```
enable
configure terminal
controller sonet 0/0/16
sts-1 1
overhead c2 10
end
```

J1 Flag

To configure the J1 flag, use the following commands:

```
enable
configure terminal
controller sonet 0/0/16
sts-1 1
```

```
overhead j1 expected length
end
```

Configuring Path Threshold

To configure path threshold, use the following commands:

```
enable
configure terminal
controller sonet 0/0/16
sts-1 1
threshold b3-tca 3
end
```

Monitoring Protection Switching Count for Protected SONET Interface

Table 43: Table 1. Feature History

Feature Name	Release Information	Feature Description
Protection Switching Count for Protected SONET Interface	Cisco IOS XE 17.15.1	In SONET networks with redundancy, Automatic Protection Switching (APS) seamlessly transitions traffic between working and standby protection links, typically due to circuit failures or other disruptions. Each switching event is tracked using the Protection Switching Count (PSC) parameter. This parameter allows network operators to monitor and analyze the frequency of these switches in real-time. By examining the PSC count, users can diagnose the network to identify the root causes of frequent switching events and implement necessary corrective actions. This advanced capability significantly enhances network reliability and performance, offering users a robust and efficient solution for maintaining optimal service quality.

In addition to SONET alarms, the Protection Switching Count (PSC) parameter records the number of times that a SONET traffic is switched between working and protection SONET circuits automatically. The switching count can be monitored and tracked as part of performance monitoring at 15-minute and 24-hour intervals. A higher PSC value serves as an alert, prompting administrators to investigate the SONET network for failures and implement corrective actions to restore optimal performance.

Supported Interface Module for PSC Monitoring

PSC monitoring is supported on these interface modules:

- A900-IMA3G-IMSG
- A900-IMA1Z8S-CXMS

Viewing the PSC Parameter

You can view the PSC parameter under the **SONET Section Tables** area of the **show controller sonet** and **show controller sonet tabular** commands.

In the show output example where the performance monitoring is set for a period of 15-minutes, you can view the PSC value of 2. This indicates that switching occurred twice every 15 minutes, with a total switching count of 4 on the SONET interface.

```
Router#show controller sonet 0/3/1
SONET 0/3/1 is up.(Configured for Locally Looped)
  Currently in Locally Looped
  Alarm-profile: telcordia
  Sec-admin-state: maintenance, Soak-time: NA,
  soak-Time-left: NA, AINS-state: OOS-MA,LPBK & MT
  Hardware is A900-IMA1Z8S-CXMS

 Port configured rate: OC3
 Applique type is Channelized Sonet
 Clock Source is Internal
Medium info:
  Type: Sonet, Line Coding: NRZ,
 Alarm Throttling: OFF
 SECTION:
  LOS = 1          LOF = 0                           BIP(B1) = 0

SONET Section Tables
  INTERVAL       CV    ES   SES  SEFS    PSC
  20:46-20:53     0    170  170   170    2 (Invalid)
  20:31-20:46     0    559  559   559    2 (Invalid)
Total of Data in Current and Previous Intervals
                  0    729  729  729     4 (Invalid)

LINE:
  AIS = 0          RDI = 0          REI = 12         BIP(B2) = 36
Active Defects: None
Detected Alarms: None
Asserted/Active Alarms: None
Alarm reporting enabled for: SLOS SLOF LAIS SF SD LRDI B1-TCA B2-TCA
BER thresholds:  SF = 10e-3  SD = 10e-6
TCA thresholds:  B1 = 10e-6  B2 = 10e-6
Rx: S1S0 = NA
    K1 = 00,   K2 = 00
    J0 = 00

    RX S1 = 00

Tx: S1S0 = NA
    K1 = 00,   K2 = 00
    J0 = 04

Tx J0 Length : 64
Tx J0 Trace :

  52 6F 75 74 65 72 20 20 20 20 20 20 20 20 20 20     Router
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 00 00                   ..

Expected J0 Length : 64
Expected J0 Trace :

  52 6F 75 74 65 72 20 20 20 20 20 20 20 20 20 20     Router
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
```

```
  20 20 20 20 20 20 20 20 20 20 20 20 20 00 00                    ..

Rx J0 Length : 64
Rx J0 Trace :

  52 6F 75 74 65 72 20 20 20 20 20 20 20 20 20     Router
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
  20 20 20 20 20 20 20 20 20 20 20 20 20 0D 00                    ..

SONET Line Tables
  INTERVAL       CV    ES   SES   UAS  CVFE  ESFE  SESFE  UASFE
  02:35-02:47     0     5     5     0     0     0      0      0  (NE, FE Invalid)


PATH 1:
Clock Source is internal

  AIS = 0          RDI = 0          REI = 0          BIP(B3) = 0
  LOM = 0          PLM = 0          UNEQ = 0          LOP = 0

Active Defects: None
Detected Alarms: None
Asserted/Active Alarms: None
Alarm reporting enabled for: PAIS PRDI PUNEQ PLOP PPLM LOM B3-SF B3-SD B3-TCA

BER threshold:  SF = 10e-3  SD = 10e-6
TCA threshold:  B3 = 10e-6
Rx: C2 = 00
Tx: C2 = 00

Tx J1 Length : 64
Tx J1 Trace

  52 6F 75 74 65 72 20 30 2F 33 2F 31 2E 31 00 00     Router 0/3/1.1..
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

Expected J1 Length : 64
Expected J1 Trace

  52 6F 75 74 65 72 20 30 2F 33 2F 31 2E 31 00 00     Router 0/3/1.1..
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

Rx J1 Length : 0
Rx J1 Trace


PATH 2:
Clock Source is internal

  AIS = 0          RDI = 0          REI = 0          BIP(B3) = 0
  LOM = 0          PLM = 0          UNEQ = 0          LOP = 0

Active Defects: None
Detected Alarms: None
Asserted/Active Alarms: None
Alarm reporting enabled for: PAIS PRDI PUNEQ PLOP PPLM LOM B3-SF B3-SD B3-TCA

BER threshold:  SF = 10e-3  SD = 10e-6
TCA threshold:  B3 = 10e-6
```

```
Rx: C2 = 00
Tx: C2 = 00

Tx J1 Length : 64
Tx J1 Trace

  52 6F 75 74 65 72 20 30 2F 33 2F 31 2E 32 00 00     Router 0/3/1.2..
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

Expected J1 Length : 64
Expected J1 Trace

  52 6F 75 74 65 72 20 30 2F 33 2F 31 2E 32 00 00     Router 0/3/1.2..
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

Rx J1 Length : 0
Rx J1 Trace


PATH 3:
Clock Source is internal

  AIS = 0          RDI = 0          REI = 0          BIP(B3) = 0
  LOM = 0          PLM = 0          UNEQ = 0          LOP = 0

Active Defects: None
Detected Alarms: None
Asserted/Active Alarms: None
Alarm reporting enabled for: PAIS PRDI PUNEQ PLOP PPLM LOM B3-SF B3-SD B3-TCA

BER threshold:  SF = 10e-3  SD = 10e-6
TCA threshold:  B3 = 10e-6
Rx: C2 = 00
Tx: C2 = 00

Tx J1 Length : 64
Tx J1 Trace

  52 6F 75 74 65 72 20 30 2F 33 2F 31 2E 33 00 00     Router 0/3/1.3..
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

Expected J1 Length : 64
Expected J1 Trace

  52 6F 75 74 65 72 20 30 2F 33 2F 31 2E 33 00 00     Router 0/3/1.3..
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

Rx J1 Length : 0
Rx J1 Trace
```

Viewing the PSC Parameter from the Detailed Show Output

The **show controller sonet tabular** command displays a detailed output of the SONET configuration along with the PSC value that can be viewed under the **SONET Section Tables** area.

In the show output example where the performance monitoring is set for a period of 15-minutes, you can view the PSC value of 1. This indicates that switching occurred once every 15 minutes, with a total switching count of 2 on the SONET interface.

```
Router#show controller sonet 0/3/1 tabular
SONET 0/3/1 is up.(Configured for Locally Looped)
  Currently in Locally Looped
  Hardware is A900-IMA3G-IMSG

 Port configured rate: OC3
 Applique type is Channelized Sonet
 Clock Source is Internal
Medium info:
  Type: Sonet, Line Coding: NRZ,
 Alarm Throttling: OFF
 SECTION:
  LOS = 1          LOF = 0                          BIP(B1) = 0

SONET Section Tables
  INTERVAL       CV-S    ES-S   SES-S  SEFS-S    PSC
  12:15-12:29       0       0       0       0      0
  12:00-12:15       0       0       0       0      0
  11:45-12:00       0       0       0       0      0
  11:30-11:45       0     404     404     404      1
  11:15-11:30       0     619     619     619      1
  11:00-11:15       0       0       0       0      0
  10:45-11:00       0     711     711     711      0
  10:30-10:45       0     656     656     656      0  (Invalid)
Total of Data in Current and Previous Intervals
                    0    2390    2390    2390      2  (Invalid)

LINE:
  AIS = 0          RDI = 0          REI = 12         BIP(B2) = 36
Active Defects: None
Detected Alarms: None
Asserted/Active Alarms: None
Alarm reporting enabled for: SLOS SLOF LAIS SF SD LRDI B1-TCA B2-TCA
BER thresholds:  SF = 10e-3  SD = 10e-6
TCA thresholds:  B1 = 10e-6  B2 = 10e-6
Rx: S1S0 = NA
    K1 = 00,   K2 = 00
    J0 = 00

    RX S1 = 00

Tx: S1S0 = NA
    K1 = 00,   K2 = 00
    J0 = 04

Tx J0 Length : 64
Tx J0 Trace :

  52 6F 75 74 65 72 20 20 20 20 20 20 20 20 20 20     Router
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 00 00                   ..

Expected J0 Length : 64
Expected J0 Trace :

  52 6F 75 74 65 72 20 20 20 20 20 20 20 20 20 20     Router
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
```

```
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 00 00                  ..

Rx J0 Length : 64
Rx J0 Trace :

  52 6F 75 74 65 72 20 20 20 20 20 20 20 20 20     Router
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
  20 20 20 20 20 20 20 20 20 20 20 20 20 20 0D 00                  ..

SONET Line Tables
  INTERVAL     CV-L  ES-L  SES-L  UAS-L  CV-LFE  ES-LFE  SES-LFE  UAS-LFE
  02:35-02:48     0     5      5      0       0       0        0        0  (NE, FE Invalid)



PATH 1:
Clock Source is internal

  AIS = 0          RDI = 0          REI = 0          BIP(B3) = 0
  LOM = 0          PLM = 0          UNEQ = 0          LOP = 0

Active Defects: None
Detected Alarms: None
Asserted/Active Alarms: None
Alarm reporting enabled for: PAIS PRDI PUNEQ PLOP PPLM LOM B3-SF B3-SD B3-TCA

BER threshold:  SF = 10e-3  SD = 10e-6
TCA threshold:  B3 = 10e-6
Rx: C2 = 00
Tx: C2 = 00

Tx J1 Length : 64
Tx J1 Trace

  52 6F 75 74 65 72 20 30 2F 33 2F 31 2E 31 00 00     Router 0/3/1.1..
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

Expected J1 Length : 64
Expected J1 Trace

  52 6F 75 74 65 72 20 30 2F 33 2F 31 2E 31 00 00     Router 0/3/1.1..
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

Rx J1 Length : 0
Rx J1 Trace


PATH 2:
Clock Source is internal

  AIS = 0          RDI = 0          REI = 0          BIP(B3) = 0
  LOM = 0          PLM = 0          UNEQ = 0          LOP = 0

Active Defects: None
Detected Alarms: None
Asserted/Active Alarms: None
Alarm reporting enabled for: PAIS PRDI PUNEQ PLOP PPLM LOM B3-SF B3-SD B3-TCA

BER threshold:  SF = 10e-3  SD = 10e-6
```

```
TCA threshold:  B3 = 10e-6
Rx: C2 = 00
Tx: C2 = 00

Tx J1 Length : 64
Tx J1 Trace

  52 6F 75 74 65 72 20 30 2F 33 2F 31 2E 32 00 00     Router 0/3/1.2..
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

Expected J1 Length : 64
Expected J1 Trace

  52 6F 75 74 65 72 20 30 2F 33 2F 31 2E 32 00 00     Router 0/3/1.2..
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

Rx J1 Length : 0
Rx J1 Trace


PATH 3:
Clock Source is internal

  AIS = 0          RDI = 0          REI = 0          BIP(B3) = 0
  LOM = 0          PLM = 0          UNEQ = 0          LOP = 0

Active Defects: None
Detected Alarms: None
Asserted/Active Alarms: None
Alarm reporting enabled for: PAIS PRDI PUNEQ PLOP PPLM LOM B3-SF B3-SD B3-TCA

BER threshold:  SF = 10e-3  SD = 10e-6
TCA threshold:  B3 = 10e-6
Rx: C2 = 00
Tx: C2 = 00

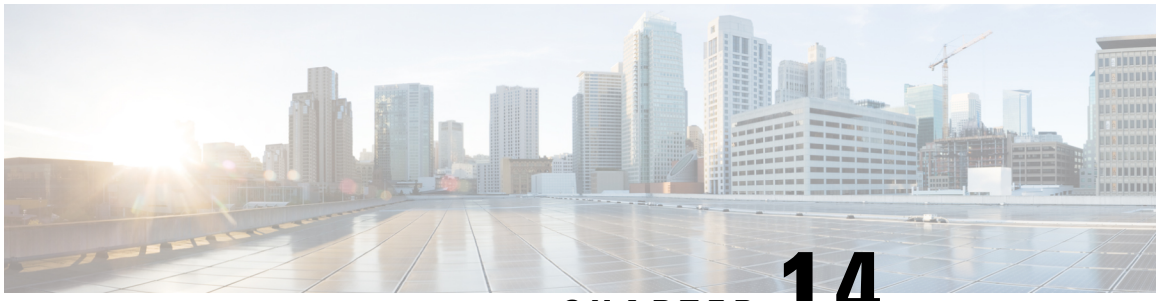
Tx J1 Length : 64
Tx J1 Trace

  52 6F 75 74 65 72 20 30 2F 33 2F 31 2E 33 00 00     Router 0/3/1.3..
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

Expected J1 Length : 64
Expected J1 Trace

  52 6F 75 74 65 72 20 30 2F 33 2F 31 2E 33 00 00     Router 0/3/1.3..
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................
  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00     ................

Rx J1 Length : 0
Rx J1 Trace
```



CHAPTER 14

Configuring MSP

Multiplex Section Protection (MSP) is a protection mechanism for SDH networks that enables SDH connections to switch to another SDH circuit when a port failure occurs. A protection interface serves as the backup interface for the working interface. When the working interface fails, the protection interface quickly assumes its traffic load.

The SDH protection schemes partially comply with ITU-T G.707 standard. It allows Optical Interface Module to work seamlessly as SDH Add or Drop Multiplexers (ADMs). The implementation of the above protection schemes allows a pair of SDH lines or paths to be configured for line or path redundancy. In the event of a fiber cut, the active line or path switches automatically to the standby line or path up to 60 milliseconds (2/5/10 millisecond for holdover and 50 millisecond switchovers).

Optical Interface Module supports the following SDH protection switching schemes:

- Linear Bidirectional 1+1 MSP
- Linear Unidirectional 1+1 MSP

- 1+1 MSP, on page 265
- Benefits of MSP, on page 266
- Restrictions for MSP, on page 266
- MSP 1+1 for SDH Layer 1 traffic , on page 266
- Scenario for Bidirectional MSP 1+1, on page 267
- Scenario for Unidirectional MSP 1+1, on page 267
- Configuring MSP for SAToP, on page 267
- Configuring MSP for CESoPSN, on page 270

1+1 MSP

In the 1+1 architecture, there is one working interface (circuit) and one protection interface, and the same payload from the transmitting end is sent to both the receiving ends. The receiving end decides which interface to use. The line overhead (LOH) bytes (K1 and K2) in the SDH frame indicate both status and action.

The protection interfaces need to be configured with an IP address of the chassis that has the working interface, using MSP commands. The MSP Protect Group Protocol, which runs on top of UDP, provides communication between the process controlling the working interface and the process controlling the protection interface. Using this protocol, interfaces can be switched because of a chassis failure, degradation or loss of channel signal, or manual intervention. In bidirectional mode, the receive and transmit channels are switched as a pair.

Two SDH connections are required to support MSP.

The following option is available for linear bidirectional 1+1 MSP:

- Revertive option — For any failure on working line, the software switches to protection line and when the working line recovers, it waits based on the revertive timer and reverts back to working line as active link.
- Non-revertive option — When the signal fails, the software switches to the protection line and does not automatically revert back to the working line. This is the default option.

The following features are supported on 1+1 MSP:

- SDH PW (SAToP or CEP)
- SDH local connect

Benefits of MSP

The following lists the benefits of MSP:

- MSP performs switchovers with minimal loss of data, and time-consuming reroutes are avoided.
- There is no visibility that a failure has occurred beyond the network element in which it is residing; other nodes are not affected by the failure.
- Implementation of MSP guards a network against complex restarts and resynchronizations since failures are isolated to a local device.
- With MSP, the effect of a failure is greatly minimized, and a fast switchover guarantees minimal effect on the network.

Restrictions for MSP

- MSP is supported on all the ports except on the 8th port with STM-64.
- Loopback, BERT, ACR and DCR, and Clocking should be configured on physical member controllers.

MSP 1+1 for SDH Layer 1 traffic

SDH linear MSP 1+1 provides protection against both fiber cuts and front card or back card failures. MSP 1+1 requires a redundant protection line for every working line. The traffic is simultaneously carried by the working and the protection lines. Hence, the receiver that terminates the MSP 1+1 should select the traffic from one of the line and continue to forward the traffic. MSP 1+1 provides protection in unidirectional and bi-directional modes:

- **Uni-directional Protection**: The receiving end can switch from working to protection line without any coordination at the transmit end since both lines transmit the same information.
- **Bi-directional Protection**: The receiving end switches from working to protection line by coordinating at the transmit end.

Scenario for Bidirectional MSP 1+1

In the above figure, two are connected to provide MSP 1+1 bi-directional protection. The highlighted one is the working line and the other is the protection line. The traffic is transmitted on both working and protection lines and received only on one line.

In a scenario where you encounter a fiber cut,

1. There is a cable cut in the working line. So, the receives a Loss of Signal (LOS) on working line.
2. starts generating K2 byte and sends it to the over the protection line.
3. receives the K2 byte and reacts on the receiving K2 byte.
4. starts sending K1 byte to the on the protection line.
5. starts sending K2 byte to on the protection line.
6. receives the K1/K2 byte and starts receiving the data from protection line. The protection line now acts as the active line.
7. sends K2 byte over the new active line to . receives this signal and starts accepting the data from this new active line.

Scenario for Unidirectional MSP 1+1

In the above figure, two are connected to provide MSP 1+1 unidirectional protection. The figure shows a working line and a protection line. The traffic is transmitted on both working and protection line and received only on one line.

In a scenario where you encounter a fiber cut,

1. receives a LOS on RX working line.
2. detects LOS and starts receiving the data from the protection line. The protection line now becomes the active line.
3. receives the K2 byte and knows about switching event on device 2.

Configuring MSP for SAToP

This section describes the configuration of MSP.

Configuring Bi-directional MSP (SDH Framing)

To configure bi-directional MSP (SDH Framing):

```
enable
configure terminal
controller MediaType 0/5/0
mode sdh
controller sdh 0/4/0
clock source internal
```

```
aps group acr 1
aps working 1
exit
controller sdh 0/5/0
aps group acr 1
aps protect 1 10.7.7.7
end
```



Note To restore the system to its default condition, use the **no** form of the command.



Note '10.7.7.7' is the loopback interface IP address on the same router.

Configuring Revertive Mode

To configure revertive mode:

```
enable
configure terminal
controller MediaType 0/5/0
mode sdh
controller sdh 0/5/0
clock source internal
aps group acr 1
aps working 1
exit
controller sdh 0/5/0
aps group acr 1
aps protect 1 10.7.7.7
aps revert 3
aps adm
end
```



Note 3 is the time in minutes for reverting back to the working port after it becomes available.

Configuring Unidirectional MSP (SDH Framing)

To configure unidirectional MSP (SDH Framing):

```
enable
configure terminal
controller MediaType 0/5/0
mode sdh
controller sdh 0/5/0
clock source internal
aps group acr 1
aps working 1
exit
controller sdh 0/5/0
aps group acr 1
aps protect 1 10.7.7.7
aps unidirectional
aps adm
end
```

Note To restore the system to its default condition, use the **no** form of the command.

APS operational commands are supported only on protect controller. The following are the operational commands for MSP with APS.

- **aps lockout**:

  This command locks the switch to protect port so that APS does not switch to protect controller for any failure on working port or IM.

- **aps force** *1*:

  This command forces the traffic to switch from active working controller to switch to protect controller.

- **aps force** *0*:

  This command forces the traffic to switch from active protect controller to switch to working controller.

- **aps manual** *1*:

  This command switches the traffic from active protect controller to work controller in the absence of **aps force** and **aps lockout** commands.

- **aps manual** *0*:

  This command switches the traffic from active protect controller to work controller in the absence of **aps force** and **aps lockout** commands.

Verifying MSP Configuration for SAToP

Use **show aps** and **show cem circuit** commands to verify MSP configuration:

```
Device#show aps
SDH 0/4/6 APS Group 1: protect channel 0 (Active)
 Working channel 1 at 10.1.1.1 (Disabled)
  bidirectional, non-revertive
  PGP timers (default): hello time=1; hold time=3
  hello fail revert time=120
 SDH framing; SDH MSP signalling by default
 Received K1K2: 0x21 0x15
  Reverse Request (working); Bridging working
 Transmitted K1K2: 0x11 0x10
  Do Not Revert (working); Bridging working
 Remote APS configuration: (null)
SDH 0/3/6 APS Group 1: working channel 1 (Inactive)
 Protect at 10.1.1.1
 PGP timers (from protect): hello time=1; hold time=3
 SDH framing
 Remote APS configuration: (null)
Device#
```

```
Device#show cem circuit int cem-acr 1 1
CEM-ACR1, ID: 1, Line: UP, Admin: UP, Ckt: ACTIVE
Controller state: up, CEP state: up
Idle Pattern: 0xFF, Idle CAS: 0x8
Dejitter: 6 (In use: 0
)Payload Size: 783
Framing: Not-Applicable
```

```
CEM Defects Set
None
Signalling: No CAS
RTP: No RTP
Ingress Pkts:    111851780           Dropped:             0
Egress Pkts:     111851778           Dropped:             0
CEM Counter Details
Input Errors:    0                   Output Errors:       0
Pkts Missing:    0                   Pkts Reordered:      0
 Misorder Drops:  0                   JitterBuf Underrun:  0
Error Sec:       0                   Severly Errored Sec: 0
Unavailable Sec: 0                   Failure Counts:      0
Pkts Malformed:  0                   JitterBuf Overrun:   0
Generated Lbits: 0                   Received Lbits:      0
Generated Rbits: 0                   Received Rbits:      0
Generated Nbits: 10950               Received Nbits:      9093
Generated Pbits: 0                   Received Pbits:      0
Device#
```

Configuring MSP for CESoPSN

This section describes the configuration of MSP for CESoPSN.

Configuring CEM Group for MSP on Virtual ACR AU3-T1 in CESoPSN

To configure CEM group on MSP, use the following commands:

```
enable
configure terminal
controller sdh-acr 200
aug mapping au-3
au-3 1
mode vc1x
Tug-2 1 payload vc11
T1 1 cem-group 0 timeslots 1 - 7
```

To configure the working controller, use the following commands:

```
enable
configure terminal
controller sdh 0/3/6
au-3 1
Tug-2 1 payload vc11
vc 1 overhead v5 2
```

To configure the protect controller, use the following commands:

```
enable
configure terminal
controller sdh 0/4/6
au-3 1
Tug-2 1 payload vc11
vc 1 overhead v5 2
```

Verifying CEM Group for MSP on Virtual ACR AU3-T1 in CESoPSN

This section includes show command to verify CEM Group for MSP on Virtual ACR AU3-T1 in CESoPSN:

```
Router# show cem circuit interface cem-acr 1

CEM-ACR1, ID: 0, Line: UP, Admin: UP, Ckt: ACTIVE
Path Mode : VC1X,Payload:VC11, AU3: 1, TUG-2: 1, T1: 1,CEM Mode: T1-CESoP
Controller state: up, T1/E1 state: up
Idle Pattern: 0xFF, Idle CAS: 0x8
Dejitter: 6 (In use: 0)
Payload Size: 192
Framing: Framed (DS0 channels: 1-24)
CEM Defects Set
None

Signalling: No CAS
RTP: No RTP

Ingress Pkts:    54113124            Dropped:             0
Egress Pkts:     54112259            Dropped:             0

CEM Counter Details
Input Errors:    0                   Output Errors:       0
Pkts Missing:    0                   Pkts Reordered:      0
Misorder Drops:  0                   JitterBuf Underrun:  869
Error Sec:       0                   Severly Errored Sec: 0
Unavailable Sec: 0                   Failure Counts:      28
Pkts Malformed:  0                   JitterBuf Overrun:   0
Generated Lbits: 0                   Received Lbits:      0
Generated Rbits: 868                 Received Rbits:      1830
Generated Mbits: 146392              Received Mbits:      232588
```

Configuring CEM Group for MSP on Virtual ACR AU4-E1 in CESoPSN

To configure CEM group on MSP, use the following commands:

```
enable
configure terminal
controller sdh-acr 200
aug mapping au-4
au-4 1
mode tug-3
tug-3 1
mode vc1x
Tug-2 1 payload vc12
e1 1 cem-group 0 timeslots 1 - 7
```

To configure the working controller, use the following commands:

```
enable
configure terminal
controller sdh 0/3/6
au-4 1
tug-3 1
Tug-2 1 payload vc12
vc 1 overhead v5 2
```

To configure the protect controller, use the following commands:

```
enable
configure terminal
controller sdh 0/4/6
au-4 1
tug-3 1
Tug-2 1 payload vc12
vc 1 overhead v5 2
```

Verifying CEM Group for MSP on Virtual ACR AU4-E1 in CESoPSN

This section includes show command to verify CEM group for MSP on Virtual ACR AU4-E1 in CESoPSN:

```
Router# show cem circuit interface cem-acr 1

CEM-ACR1, ID: 0, Line: UP, Admin: UP, Ckt: ACTIVE
Path Mode : VC1X,Payload:VC11, AU4: 1, TUG-3: 1, E1: 1,CEM Mode: E1-CESoP
Controller state: up, T1/E1 state: up
Idle Pattern: 0xFF, Idle CAS: 0x8
Dejitter: 6 (In use: 0)
Payload Size: 56
Framing: Framed (DS0 channels: 1-7)
CEM Defects Set
None

Signalling: No CAS
RTP: No RTP

Ingress Pkts:    54113124            Dropped:             0
Egress Pkts:     54112259            Dropped:             0

CEM Counter Details
Input Errors:    0                   Output Errors:       0
Pkts Missing:    0                   Pkts Reordered:      0
Misorder Drops:  0                   JitterBuf Underrun:  869
Error Sec:       0                   Severly Errored Sec: 0
Unavailable Sec: 0                   Failure Counts:      28
Pkts Malformed:  0                   JitterBuf Overrun:   0
Generated Lbits: 0                   Received Lbits:      0
Generated Rbits: 868                 Received Rbits:      1830
Generated Mbits: 146392              Received Mbits:      232588
```

Configuring Clocking ACR for MSP AU3-T1 in CESoPSN

To configure clock source on MSP for the working controller, use the following commands:

```
enable
configure terminal
controller sdh 0/3/6
au-3 1
tug-2 1 payload vc11
t1 1 clock source recovered 1
end
```

To configure the recovered clock, use the following commands:

```
enable
configure terminal
```

```
recovered-clock acr 200
clock recovered 1 adaptive cem 1 priority 1
end
```

To configure clock source on MSP for the protect controller, use the following commands:

```
enable
configure terminal
controller sdh 0/4/6
au-3 1
tug-2 1 payload vc11
t1 1 clock source recovered 1
end
```

To configure the recovered clock, use the following commands:

```
enable
configure terminal
recovered-clock acr 200
clock recovered 1 adaptive cem 2 priority 2
end
```

Verifying Clocking ACR for MSP AU3-T1 in CESoPSN

Use the show recovered-clock command to verify the ACR for AU3-T1 in CESoPSN:

```
Router# show recovered-clock

Recovered clock status for MSP-ACR 200
---------------------------------------
Clock    Type     Mode        CEM    Status        Circuit-No           Working     Protect
   Priority
4     OCx-T1   ADAPTIVE     38   ACQUIRING  200/3/1/1(acr/path/vtg/t1) ACQUIRING  ACQUIRING
  1
```

Configuring Clocking DCR for MSP AU3-T1 in CESoPSN

To configure clock source on MSP for the working controller, use the following commands:

```
enable
configure terminal
controller sdh 0/3/6
au-3 1
tug-2 1 payload vc11
t1 1 clock source recovered 1
end
```

To configure CEM interface, use the following commands:

```
interface cem <bay>/<slot>/<port>
cem <cem-group-no>
rtp-present
```

To configure the recovered clock with priority 1, use the following commands:

```
enable
configure terminal
recovered-clock acr 200
```

```
clock recovered 1 differential cem 1 priority 1
end
```

To configure clock source on MSP for the protect controller, use the following commands:

```
enable
configure terminal
controller sdh 0/4/6
au-3 1
tug-2 1 payload vc11
t1 1 clock source recovered 1
end
```

To configure CEM interface, use the following commands:

```
interface cem <bay>/<slot>/<port>
cem <cem-group-no>
rtp-present
```

To configure the recovered clock with priority 1, use the following commands:

```
enable
configure terminal
recovered-clock acr 200
clock recovered 1 differential cem 2 priority 2
end
```

Verifying Clocking DCR for MSP AU3-T1 in CESoPSN

Use the show recovered-clock command to verify the DCR for AU3-T1 in CESoPSN:

```
Router# show recovered-clock

Recovered clock status for MSP-DCR 200
----------------------------------------
Clock    Type     Mode        CEM    Status        Circuit-No          Working     Protect
   Priority
5     OCx-T1   DIFFERENTIAL  44   ACQUIRING  200/4/1/1(acr/path/vtg/t1) ACQUIRING  ACQUIRING
  1
```

Configuring Clocking ACR for MSP AU4-E1 in CESoPSN

To configure clock source on MSP for the working controller, use the following commands:

```
enable
configure terminal
controller sdh 0/3/6
au-4 1
tug-3 1
tug-2 1 payload vc12
e1 1 clock source recovered 5
end
```

To configure the recovered clock, use the following commands:

```
enable
configure terminal
```

```
recovered-clock acr 200
clock recovered 5 adaptive cem 1 priority 1
end
```

To configure clock source on MSP for the protect controller, use the following commands:

```
enable
configure terminal
controller sdh 0/4/6
au-4 1
tug-3 1
tug-2 1 payload vc12
e1 1 clock source recovered 5
end
```

To configure the recovered clock, use the following commands:

```
enable
configure terminal
recovered-clock acr 200
clock recovered 5 adaptive cem 2 priority 2
end
```

Verifying Clocking ACR for MSP AU4-E1 in CESoPSN

Use the show recovered-clock command to verify the ACR for AU4-E1 in CESoPSN:

```
Router# show recovered-clock
Recovered clock status for MSP-ACR 200
---------------------------------------
Clock    Type     Mode        CEM    Status        Circuit-No           Working     Protect
   Priority
4     OCx-T1   ADAPTIVE     38   ACQUIRING  200/3/1/1(acr/path/vtg/t1) ACQUIRING  ACQUIRING
  1
```

Configuring Clocking DCR for MSP AU4-E1 in CESoPSN

To configure clock source on MSP for the working controller, use the following commands:

```
enable
configure terminal
controller sdh 0/3/6
au-4 1
tug-3 1
tug-2 1 payload vc12
e1 1 clock source recovered 5
end
```

To configure CEM interface, use the following commands:

```
interface cem <bay>/<slot>/<port>
cem <cem-group-no>
rtp-present
```

To configure the recovered clock with priority 1, use the following commands:

```
enable
```

```
configure terminal
recovered-clock acr 200
clock recovered 5 differential cem 1 priority 1
end
```

To configure clock source on MSP for the protect controller, use the following commands:

```
enable
configure terminal
controller sdh 0/4/6
au-4 1
tug-3 1
tug-2 1 payload vc12
e1 1 clock source recovered 5
end
```

To configure CEM interface, use the following commands:

```
interface cem <bay>/<slot>/<port>
cem <cem-group-no>
rtp-present
```

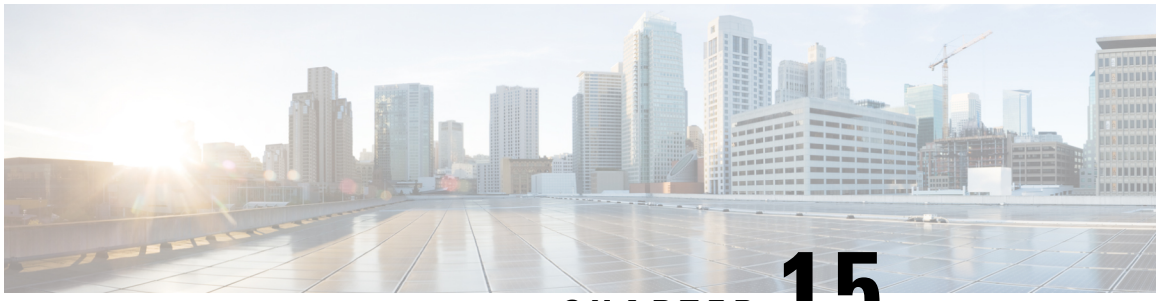
To configure the recovered clock with priority 1, use the following commands:

```
enable
configure terminal
recovered-clock acr 200
clock recovered 5 differential cem 2 priority 2
end
```

Verifying Clocking DCR for MSP AU4-E1 in CESoPSN

Use the show recovered-clock command to verify the DCR for AU4-E1 in CESoPSN:

```
Router# show recovered-clock
Recovered clock status for MSP-DCR 200
----------------------------------------
Clock    Type     Mode        CEM    Status        Circuit-No          Working     Protect
   Priority
5     OCx-T1   DIFFERENTIAL  44   ACQUIRING  200/4/1/1(acr/path/vtg/t1) ACQUIRING  ACQUIRING
  1
```



CHAPTER 15

UPSR Path Protection

Table 44: Feature History

Feature Name	Release Information	Feature Description
CEM and IP IW Feature Parity for A900-IMA1Z8S-CXMS and A900-IMA3G-IMSG Interface Modules	Cisco IOS XE Bengaluru 17.4.1	Support for UPSR IPv6 on A900-IMA1Z8S-CXMS and A900-IMA3G-IMSG Interface Module.

A Unidirectional Path Switching Ring (UPSR) is a unidirectional network with two rings, one ring used as the working ring and the other as the protection ring. The same signal flows through both rings, one clockwise and the other counterclockwise. It is called UPSR because monitoring is done at the path layer. A node receives two copies of the electrical signals at the path layer, compares them, and chooses the one with the better quality. If part of a ring between two ADMs fails, the other ring still can guarantee the continuation of data flow. UPSR, like the one-plus-one scheme, has fast failure recovery.

Once a signal fail condition or a signal degrade condition is detected, the hardware initiates an interrupt to software that switches from the working path to the protection path. Nonrevertive options are valid for UPSR path protection.

Note 1X OC-192 and 8X OC-48 interface modules only supports the nonrevertive option. The nonrevertive option is the default mode.

Note When an active link of UPSR and APS is configured on the same interface module and the interface module reloads, the convergence number for UPSR circuits to switch to backup is high ranging 100–200 ms. When each circuit is configured separately, the convergence time is always under 50 ms.

The maximum scale supported on UPSR at system level is 1000 circuits.

The UPSR path protection supports the following feature:

- SONET local connect and cross connect are supported at VT-15 CEP, STS-1c, STS-3c, STS-12c, and STS-48c levels. UPSR is also supported on TDM endpoints that are mapped to a pseudowire. T1 SAToP, T3 SAToP, and CT3 are supported on an UPSR ring only with local connect mode. Cross connect of T1, T3, and CT3 circuits to UPSR are not supported until Cisco IOS XE Fuji 16.8.x.

Starting with Cisco IOS XE Fuji 16.9.x, the cross connect of T1, T3, and CT3 circuits to UPSR is supported. For xconnect with the CT3 mode, the CEM protection group interface only supports the VT-15 mode. For cross-connect configuration, see *Configuring UPSR*.

- Restrictions for iMSG UPSR Path Protection, on page 278
- Configuring iMSG UPSR, on page 278
- Configuring UPSR, on page 278

Restrictions for iMSG UPSR Path Protection

- UPSR Dual Ring Interconnect (DRI) is not supported.
- UPSR Dual Node Interconnect (DNI) is not supported.
- T1 or E1 and T3 or E3 configurations are not supported, and only the OCx-related configuration is supported.
- HDLC UPSR supports 510 PPP or HDLC pseudowire per group for an interface module and 1020 PPP or HDLC pseudowire for a router.
- APS group number of 255 and UPSR group ID of 1 cannot be configured on the same router.

Configuring iMSG UPSR

To configure protection group for iMSG UPSR, enter the following commands:

```
enable
configure terminal
protection-group 401 type STS48c
controller protection-group 401
type STS48c
channel-group 0
end
```

Configuring UPSR

Protection Group Configuration

```
enable
configure terminal
protection-group 401 type STS48c
controller protection-group 401
type STS48c
cem-group 19001 cep
end
```

Cross-connect Configuration with the CT3 mode

For cross connect with the CT3 mode, the CEM protection group interface supports only the VT-15 mode.

```
protection-group 2 type vt1.5
controller protection-group 2
```

```
type vt1.5
cem-group 16002 unframed

controller sonet 0/4/0
sts-1 1
mode vt-15
vtg 1 t1 2 protection-group 2 working

controller sonet 0/5/0
sts-1 1
mode vt-15
vtg 1 t1 2 protection-group 2 protect
```

Configuring UPSR Work and Protection Path Configuration

UPSR Work Path Configuration:

```
enable
configure terminal
controller MediaType 0/3/6
mode sonet
controller sonet 0/3/6
rate oc48
sts-1 1 - 48 mode sts-48c
protection-group 401 working
end
```

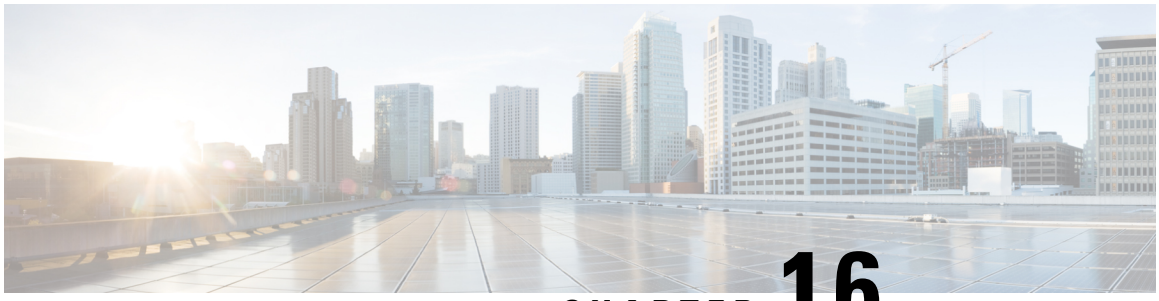
UPSR Protect Path Configuration:

```
enable
configure terminal
controller MediaType 0/12/6
mode sonet
controller sonet 0/12/6
rate oc48
sts-1 1 - 48 mode sts-48c
protection-group 401 protect
end
```

Verifying UPSR Configuration

Use the **show protection-group** command to verify UPSR configuration:

```
show protection-group
PGN   Type    Working I/f                Protect I/f              Active Status
-------------------------------------------------------------------------------
401   STS48C  SONET0/3/6.1-48            SONET0/12/6.1-48           W         A
-------------------------------------------------------------------------------
Status legend:D=Deleted FO=Force SF=SignalFailure SD=SignalDegrade
                        FL=Fail M=Manual L=Lockout C=Clear A=Auto
 (W)=working, (P)=protect
```



CHAPTER 16

Unidirectional Path Switching Ring Over HDLC

- Unidirectional Path Switching Ring Over HDLC Overview, on page 281
- Limitations for HDLC UPSR, on page 281
- How to Configure UPSR over HDLC, on page 282
- Configuration Examples for HDLC UPSR, on page 285

Unidirectional Path Switching Ring Over HDLC Overview

A Unidirectional Path Switching Ring (UPSR) is a unidirectional network with two rings, one ring used as the working ring and the other as the protection ring. The traffic on a working ring or path is always in one direction (clockwise) and on a protection path is in the opposite direction (counterclockwise). The same signal flows through both working and protection rings using a selector switch.

The UPSR monitoring is performed at the path layer. A node receives two copies of the electrical signals at the path layer, compares them, and chooses the one with the better quality. When a signal fail condition is detected, the hardware initiates an interrupt to software which switches from the working path to the protection path or the opposite way.

In an access network, the UPSR serial traffic is processed with an HDLC encapsulation protocol. The termination CE end may be Ethernet traffic. Between the access routers, the network can be a SONET network, where the data path in the network is protected by UPSR. The data terminating router in the network selects the working or protection path.

UPSR is supported on modes such as VT 1.5, STS 3c, and T3.

Limitations for HDLC UPSR

- HDLC UPSR is supported only on the 1 port OC-48/ 4 port OC-12/OC-3 + 12 port T1/E1 + 4 port T3/E3 CEM interface module.
- HDLC UPSR is applicable only for the OCx ports of the 1 port OC-48/ 4 port OC-12/OC-3 + 12 port T1/E1 + 4 port T3/E3 CEM interface module.
- Work path and protection path should be in the different interface modules.
- The modes supported for configuring HDLC UPSR are VT 1.5, T3, and STS-3c.
- The HDLC UPSR is supported only on RSP2 module.

- HDLC UPSR switching does not happen when there is any alarm at PDH level, for example T1 or T3. The switching happens at VT or STS path alarm.

How to Configure UPSR over HDLC

You can configure HDLC UPSR in anyone of the following ways:

- Create protection group first and then add working or protect member under physical controller. The channel group can be configured under protection group controller once the protection group is created.
- Add working or protect member under physical controller which creates the protection group controller. The channel group can be added under the protection group controller once protection group is created.

Configuring Protection Group

You need to create protection group serial interface.

You can create protection group for anyone of the following types: T3, VT 1.5 T1, and STS-3c.

```
enable
configure terminal
controller protection-group 401 type STS3c
channel-group chan-num timeslots 1-24
end
```

Configuring Channel Group

You can configure channel group under protection controller to create a protection group (PG) serial interface.

Creating Protection Group Serial Interface for VT 1.5 T1 Mode

Once the protection group is created, you can configure the controller using the protection group name and mode. You need to specify the channel group number with timeslots to create a PG serial interface.

To configure the channel group under the controller for VT 1.5 T1 mode, enter the following commands:

```
enable
configure terminal
controller protection-group pg_grp_num type vt1.5
channel-group chan_num timeslots 1-24
end
```

Creating Protection Group Serial Interface for T3 or STS-3c Mode

You can configure protection group for the controller mode types T3 or STS-3c using specific channel group.

To configure channel group under protection controller for mode T3, enter the following commands:

```
enable
configure terminal
protection-group pg_grp_num type sts1
controller sonet x/y/z
sts-1 3
mode t3
```

```
protection-grouppg_grp_numworking
end
```

To configure channel group under protection controller for mode types STS-3c, enter the following commands:

```
enable
configure terminal
protection-group pg_grp_num type sts1
controller sonet x/y/z
sts-3c
mode t3
protection-grouppg_grp_numworking
end
```

The following example details on how to create protection group serial interface for T3 mode:

```
Router(config)#protection-group 6 type stS1
Router(config-ctrlr-sts1)#controller sonet 0/5/17
Router(config-controller)#sts-1 3
Router(config-ctrlr-sts1)#mode t3
Router(config-ctrlr-sts1)#protection-group 6 working
```

Creating Protection Group Serial Interface for VT 1.5 T1 Mode

Once the protection group is created, you can configure the controller using the protection group name and mode. You need to specify the channel group number with timeslots to create a PG serial interface.

To configure the channel group under the controller for VT 1.5 T1 mode, enter the following commands:

```
enable
configure terminal
controller protection-group pg_grp_num type vt1.5
channel-group chan_num timeslots 1-24
end
```

Creating Protection Group Serial Interface for T3 or STS-3c Mode

You can configure protection group for the controller mode types T3 or STS-3c using specific channel group.

To configure channel group under protection controller for mode T3, enter the following commands:

```
enable
configure terminal
protection-group pg_grp_num type sts1
controller sonet x/y/z
sts-1 3
mode t3
protection-grouppg_grp_numworking
end
```

To configure channel group under protection controller for mode types STS-3c, enter the following commands:

```
enable
configure terminal
protection-group pg_grp_num type sts1
controller sonet x/y/z
sts-3c
mode t3
protection-grouppg_grp_numworking
end
```

The following example details on how to create protection group serial interface for T3 mode:

```
Router(config)#protection-group 6 type stS1
Router(config-ctrlr-sts1)#controller sonet 0/5/17
Router(config-controller)#sts-1 3
Router(config-ctrlr-sts1)#mode t3
Router(config-ctrlr-sts1)#protection-group 6 working
```

Adding Protection Group to Controller Under VT 1.5 Mode

You can add protection group as working or protect under specific SONET controller mode on the SONET controller interface.

To add protection group to SONET controller under VT 1.5 mode, enter the following commands:

```
enable
configure terminal
controller sonet <x/y/z>
sts-1 1
mode vt-15
vtg 1 t1 1
protection-group pg_grp_num type {working | protect}
end
```

Adding Protection Group to Controller Under T3 Mode

You can add protection group for T3 framing type such as M13, c-bit.

To add protection group to SONET controller under T3 mode, enter the following commands:

```
enable
configure terminal
controller sonet <x/y/z>
sts-1 1
mode t3
protection-group pg_grp_num type {working | protect}
end
```

Adding Protection Group to Controller Under STS-3c Mode

To add protection group to SONET controller under STS-3c mode, enter the following commands:

```
enable
configure terminal
controller sonet <x/y/z>
sts-1 1 - 3
mode sts-3c
protection-group pg_grp_num type {working | protect}
end
```

ConfiguringCross-ConnectUnderProtectionGroupSerialInterfacePseudowire

The **xconnect** command binds the attachment circuit to a pseudowire for cross connect service. The identifier creates the binding between a pseudowire that is configured on a PE router and an attachment circuit in a CE device.

To perform cross connection between a pseudowire and attachment circuit, use the following commands:

```
router(config)#interface serial-pg <pg-group-name>.<chan_num>
router(config-if)#xconnect ip-address id encapsulation type pw-class pw-class
```

Verifying UPSR Over HDLC Configuration

Use the following **show** commands to verify the UPSR over HDLC configuration:

```
Router#show ip int br | sec PG
Serial-PG1.0           unassigned      YES unset  up                    up
Serial-PG2.0           unassigned      YES unset  up                    up
Router#sh protection-group
PGN   Type    Working I/f                Protect I/f              Active Status
-------------------------------------------------------------------------------
1     VT15    SONET0/5/17.1/1/1                                     W         A
2     VT15    SONET0/5/17.2/2/2                                     W         A


Router#show xconnect all | sec PG
DN pri   ac Se-PG1.0(HDLC)               UP mpls 10.10.10.10:2               DN

Router#sh controller sonet 0/5/17 | sec prot
  Working member of protection-group: 1
  Working member of protection-group: 2


Router#show run | sec 0/5/17
platform enable controller MediaType 0/5/17 oc3
controller MediaType 0/5/17
mode sonet
controller SONET 0/5/17
rate OC3
no ais-shut
alarm-report all
clock source internal
!
sts-1 1
  clock source internal
  mode vt-15
  vtg 1 t1 1 protection-group 1 working
!
sts-1 2
  clock source internal
  mode vt-15
  vtg 2 t1 2 protection-group 2 working
```

Configuration Examples for HDLC UPSR

This section provides examples to configure HDLC UPSR:

Use Case 1

The following example details on how UPSR is configured over HDLC:

- Protection group of 3 configured under VT 1.5 T1 mode.

- Channel group of zero with timeslot configured under the protection group created.
- SONET controller is configured for mode VT 1.5 T1 on interface 0/5/17.
- Protection group of 3 added as working ring under SONET controller mode VT 1.5 T1.
- Perform cross connection under attachment circuit

```
Router(config)#protection-group 3 type vt1.5
Router(config)#controller protection-group 3
Router(config-controller)#type vt1.5
Router(config-ctrlr-sts1)#channel-group 0 timeslots 1-24
Router(config-ctrlr-sts1)#controller sonet 0/5/17
Router(config-controller)#sts-1 1
Router(config-ctrlr-sts1)#mode vt-15
Router(config-ctrlr-sts1)#vtg 1 t1 1 protection-group 3 working
```

Verify the configuration using the following **show** commands:

```
Router#show protection-group
PGN   Type    Working I/f                Protect I/f              Active Status
-------------------------------------------------------------------------------
1     VT15                                                          -         A
2     VT15                                                          -         A
3     VT15    SONET0/5/17.1/1/1                                     W         A
```

```
Router#show controller sonet 0/5/17 | sec protection
  Working member of protection-group: 3
```

```
Router#show ip int br | sec PG
Serial-PG3.0           unassigned      YES unset  up                    up
```

```
Router(config)#interface Serial-PG3.0
Router(config-if)#xconnect 10.10.10.10 1 encapsulation mpls pw-
Router(config-if)#$.10.10.10 1 encapsulation mpls pw-class serial_pg
```

If you want to remove the configuration performed, use the following commands:

```
Router(config-if-xconn)#int Serial-PG3.0
Router(config-if)#no xconnect

Router(config)#controller sonet 0/5/17
Router(config-controller)#sts-1 1
Router(config-ctrlr-sts1)#no vtg 1 t1 1 protection-group 3 working

Router(config)#controller protection-group 3
Router(config-controller)#type vt1.5
Router(config-ctrlr-sts1)#no channel-group 0
Router(config-ctrlr-sts1)#no protection-group 3
```

Use Case 2

The following example details on how UPSR is configured over HDLC:

- SONET controller is configured for mode VT 1.5 T1 on interface 0/5/17.
- Protection group of 3 added as working ring under SONET controller mode VT 1.5 T1.

- Protection group of 3 configured under VT 1.5 T1 mode.
- Channel group of zero with timeslot configured under the protection group created.
- Perform cross connection under attachment circuit

```
Router(config)#controller sonet 0/5/17
Router(config-controller)#sts-1 1
Router(config-ctrlr-sts1)#mode vt-15
Router(config-ctrlr-sts1)#vtg 1 t1 1 protection-group 3 working
Router(config-ctrlr-sts1)#exit
Router(config-controller)#exit
Router(config)#controller protection-group 3
Router(config-controller)#type vt1.5
Router(config-ctrlr-sts1)#channel-group 0 timeslots 1-24
```

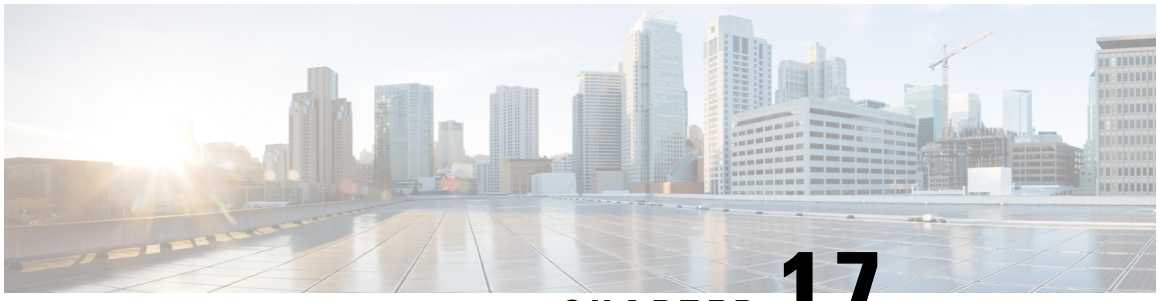
Verify the configuration using the following **show** commands:

```
Router#show protection-group
PGN   Type    Working I/f               Protect I/f              Active Status
-------------------------------------------------------------------------------
1     VT15                                                         -         A
2     VT15                                                         -         A
3     VT15    SONET0/5/17.1/1/1                                    W         A
```

```
Router#show controller sonet 0/5/17 | sec protection
  Working member of protection-group: 3
```

```
Router#show ip int br | sec PG
Serial-PG3.0           unassigned      YES unset  up                    up
```

```
Router(config)#int Serial-PG3.0
Router(config-if)#xconnect 10.10.10.10 1 encapsulation mpls pw-
Router(config-if)#$.10.10.10 1 encapsulation mpls pw-class serial_pg
```



CHAPTER 17

Configuring SNCP

SNCP is a protection mechanism for SDH networks that enables SDH connections to switch to another SDH circuit when a circuit failure occurs. A protection interface serves as the backup interface for the working interface. When the working interface fails, the protection interface quickly assumes its traffic load.

The SDH protection schemes partially comply with ITU-T G.707 standard. It allows Optical Interface Module to work seamlessly as SDH Add or Drop Multiplexers (ADMs). The implementation of the above protection schemes allows a pair of SDH lines or paths to be configured for line or path redundancy. In the event of a fiber cut, the active line or path switches automatically to the standby line or path up to 60 milliseconds (2/5/10 millisecond for holdover and 50 millisecond switchovers).

Optical Interface Module supports the following SDH protection switching schemes:

- SNCP Path Protection at STS Level
- SNCP Path Protection at VT Level

- Restrictions for SNCP, on page 289
- SNCP Path Protection, on page 289
- Configuring SNCP, on page 290
- Verification of SNCP Configuration, on page 291

Restrictions for SNCP

- SNCP is not supported on port 8 of the IM with STM-64 rate configured.
- SNCP is supported on AU-3 —VC-3 SDH mode and not supported on AU-4 —VC-3 mode.

SNCP Path Protection

SNCP is a unidirectional network with two rings, one ring used as the working ring and the other as the protection ring. The same signal flows through both rings, one clockwise and the other counterclockwise. It is called SNCP because monitoring is done at the path layer. A node receives two copies of the electrical signals at the path layer, compares them, and chooses the one with the better quality. If part of a ring between two ADMs fails, the other ring still can guarantee the continuation of data flow. SNCP, like the one-plus-one scheme, has fast failure recovery.

Once a signal fail condition or a signal degrade condition is detected, the hardware initiates an interrupt to software that switches from the working path to the protection path. Non-revertive options are valid for SNCP path protection.

Note 1X OC-192 and 8X OC-48 interface modules only supports the non-revertive option. The non-revertive option is the default mode.

The maximum scale supported on SNCP at system level is 1000 circuits.

Configuring SNCP

Protection Group Controller Configuration

```
enable
configure terminal
protection group 1 type vc4-16c
controller protection group 1
type vc4-16c
cem-group 16001 cep
end
```

Working Path Configuration

```
enable
configure terminal
controller sdh 0/3/6
au-4 1-16 mode vc4-16c
protection group 1 working
end
```

Protect Path Configuration

```
enable
configure terminal
controller sdh 0/12/6
au-4 1-16 mode vc4-16c
protection group 1 protect
end
```

CEM Group Configuration

```
enable
configure terminal
controller sdh 0/4/1
au-4 1-16 mode vc4-16c
cem-group 1 cep
end
```

Local Connect Configuration

```
enable
configure terminal
connect lc cem 0/4/1 1 cem-pg 1 16001
end
```

Verification of SNCP Configuration

Use **show protection-group** command to verify SNCP configuration:

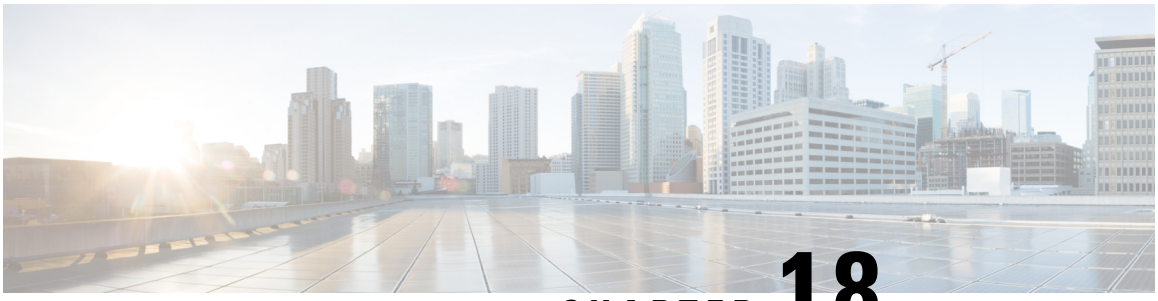
```
#show protection-group
PGN   Type    Working I/f                Protect I/f              Active Status
-------------------------------------------------------------------------------
1     VC4-16C SDH0/3/6.1-48              SDH0/12/6.1-48             P         A
-------------------------------------------------------------------------------
Status legend:D=Deleted FO=Force SF=SignalFailure SD=SignalDegrade
                        FL=Fail M=Manual L=Lockout C=Clear A=Auto
 (W)=working, (P)=protect
```



PART V

DCC and TARP

- Configuring Data Communication Channel, on page 295
- Transparent Overhead Tunneling Data Communication Channel, on page 299
- Target Identifier Address Resolution Protocol, on page 307



CHAPTER 18

Configuring Data Communication Channel

Table 45: Feature History

Feature Name	Release Information	Description
DCC Termination	Cisco IOS XE Bengaluru 17.4.1	DCC Termination is supported on the OCx ports for following interface modules: • 1-port OC-48/STM-16 or 4-port OC-12/OC-3 / STM-1/STM-4 + 12-port T1/E1 + 4-port T3/E3 module • 1-port OC-192 or 8-port low rate module • ASR 900 1-port OC-192 or 8-port low rate CEM 20G bandwidth module
DCC Support	Cisco IOS XE Amsterdam 17.3.1	The Data Communication Channel (DCC) feature uses the SONET or SDH Operation Administration and Maintenance (OAM) channel to manage devices that support SONET or SDH interfaces on the following Cisco RSP3 module: • ASR 900 1-port OC-192 or 8-port low rate CEM 20G bandwidth module

The Data Communication Channel (DCC) feature uses the SONET or SDH Operation Administration and Maintenance (OAM) channel to manage devices that support SONET or SDH interfaces. SONET or SDH standards support extensive operations, administration, management, and provisioning (OAM&P) capabilities.

The following overhead bytes are specified in the standards as the OAM channels that carry management information, alarms, and management commands:

- D1 to D3 bytes of the Section overhead

- D4 to D12 bytes of the Line overhead

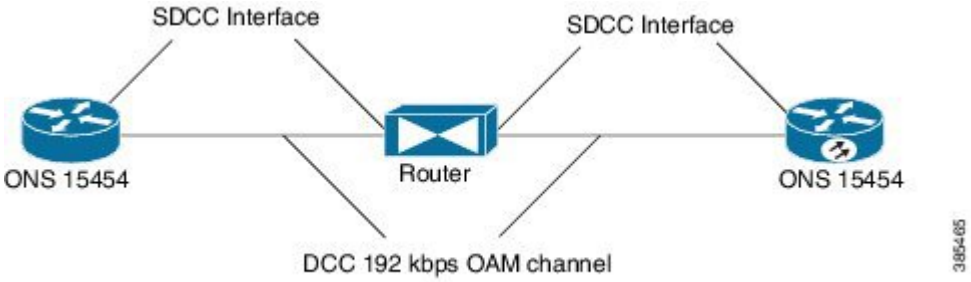
These overhead bytes are referred to as the Data Communication Channel (DCC). The Line-level DCC is a 576 kbps OAM channel; the Section-level DCC is a 192 kbps OAM channel. DCC feature uses the data communications channel to access network devices that are connected through SONET/SDH interfaces for management access.

ITU-G.7712 has defined the following three DCC network domains:

- OSI DCC network
- IP DCC network
- OSI+IP DCC network

Effective Cisco IOS XE Everest 16.6.1 release, only OSI DCC network and IP DCC network are supported, which implies that same type of network resides on either side of the router.

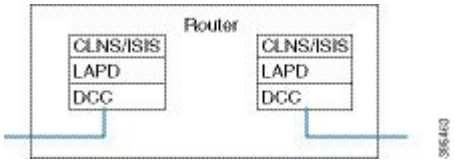
Figure 7: Implementation of DCC



As shown in the figure above, the logical interface for DCC channels is called a SONET Data Communications Channel (SDCC). Each SDCC interface is assigned an IP address. The Routing Information Protocol (RIP) is used as the routing protocol for the IP DCC network.

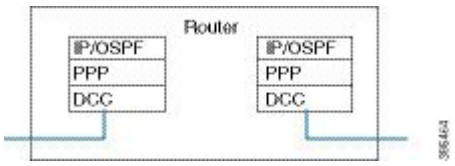
For OSI network, CLNS or ISIS protocol is used for routing and node discovery. The data layer encapsulation is LAPD.

Figure 8: DCC for OSI Network



For IP netwok, IP or OSPF protocol is used for routing and node discovery. The data layer encapsulation is PPP.

Figure 9: DCC for IP Network



Static IP configuration and PPP authentication are also supported. DCC also works with APS 1+1 protection infrastructure.

- Restrictions of DCC, on page 297
- Configuring PPP, on page 297
- Configuring CLNS or LAPD, on page 298
- Verification of DCC Configuration, on page 298

Restrictions of DCC

- Only routing IP and OSI domains are supported; layers 4–7 of OSI model is not supported.
- DCC is not supported on ASR 900 1-Port OC-192 or 8-Port Low Rate CEM 20G Bandwidth interface module in release Cisco IOS XE Cupertino 17.8.1.
- Interworking of OSPI and IP domains is not supported.
- CLNS MTU supported is 1489 on routers.
- CLNS interoperability with ONS is not supported.
- IS-IS packet bigger than LAPD MTU is dropped.
- 1+1 APS with CLNS mode is not supported.
- During a CRC mismatch, the interface reaches **Up** state under the LAPD UITS mode after SSO.
- Under LAPD encapsulation mode, the default LAPD role and modes are not displayed in the running configuration.
- DCC termination on APS controllers is not supported.
- The maximum number of pseudowires including TOH that you can provision on A900-IMA1Z8S-CXMS and A900-IMA1Z8S-CX is 5376.

Configuring PPP

To configure PPP:

```
enable
configure terminal
controller mediatype 0/3/4
mode sonet
controller sonet 0/3/4
rate oc48
dcc enable [section | line]
interface [sdcc | ldcc] 0/3/4
ip unnumbered loopback 1
encapsulation ppp
exit
interface loopback 1
ip address 10.2.2.2 255.0.0.0
router ospf 1
network 10.2.2.0 255.0.0.0 area 0
end
```

Configuring CLNS or LAPD

To configure CLNS or LAPD:

```
enable
configure terminal
controller mediatype 0/3/4
mode sonet
controller sonet 0/3/4
rate oc48
dcc enable [section | line]
interface [sdcc | ldcc] 0/3/4
encapsulation lapd
clns mtu 512
lapd role user
clns router isis R1_R2
router isis R1_R2
net 47.0039.3333.3333.3333.00
end
```

Note When you configure LAPD role user on router, you should not configure the other router as LAPD role user. It should be network and not user.

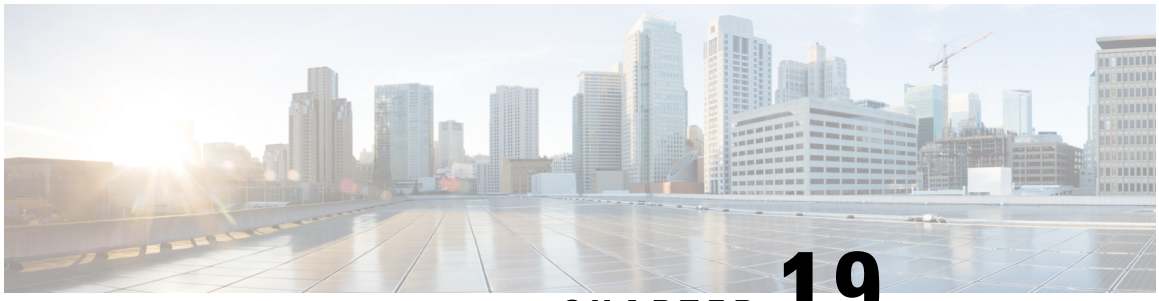
Verification of DCC Configuration

Use **show clns neighbors**, **show ip ospf neighbor**, **show ip int br | I DCC**, and **show interface SDCC** commands to verify DCC configuration.

```
#show clns neighbors
Tag R1_R2:

Tag null:
System Id       Interface     SNPA                State  Holdtime  Type Protocol
NCS4216_2       LD0/3/4       *LAPD*              Up     9         L1L2 IS-IS

Tag ethernet:
System Id       Interface     SNPA                State  Holdtime  Type Protocol
NCS4216_1       Te0/1/8       5006.ab62.6062      Up     54        L1   IS-IS
#show ip ospf neighbor
Neighbor ID     Pri   State           Dead Time   Address         Interface
10.3.3.4          1   FULL/BDR        00:00:35    10.3.3.4         TenGigabitEthernet0/1/8
10.6.6.2          0   FULL/  -        00:00:37    10.2.2.1          SDCC0/3/4
#show ip int br | i DCC
LDCC0/3/4              10.5.5.2         YES NVRAM  up                    up
SDCC0/3/6              10.2.2.1         YES TFTP   up                    down
SDCC0/3/7              10.2.2.1         YES TFTP   up                    up
SDCC0/4/7              10.8.8.8         YES TFTP   down                  down
```



CHAPTER 19

Transparent Overhead Tunneling Data Communication Channel

This chapter provides information about the transparent overhead tunneling data communication channel.

- Transparent Overhead Tunneling Data Communication Channel Overview, on page 299
- Transparent Overhead Tunnel DCC Types, on page 300
- Prerequisites for Transparent Overhead Tunnel, on page 301
- Limitations of Transparent Overhead Tunnel, on page 302
- How to Configure Transparent Overhead Tunnel, on page 303

Transparent Overhead Tunneling Data Communication Channel Overview

SONET or SDH frame provides data communications channel (DCC) bytes for network element operations such as administration, maintenance, and provisioning.

Each SONET or SDH frame includes two DCCs—Section DCC (SDCC or RS-DCC) and Line DCC (LDCC or MS-DCC). The section and line DCCs are used for transporting management messages between Network Elements (NEs) and between NEs and Network Management System (NMS).

Each SONET or SDH frame uses these DCC bytes in overhead of the frame to carry management information for SONET or SDH networks, or Add or Drop multiplexers (ADMs). These DCC bytes traverse through hop-by-hop between ADMs and perform a path discovery and end-to-end provisioning in SONET or SDH network.

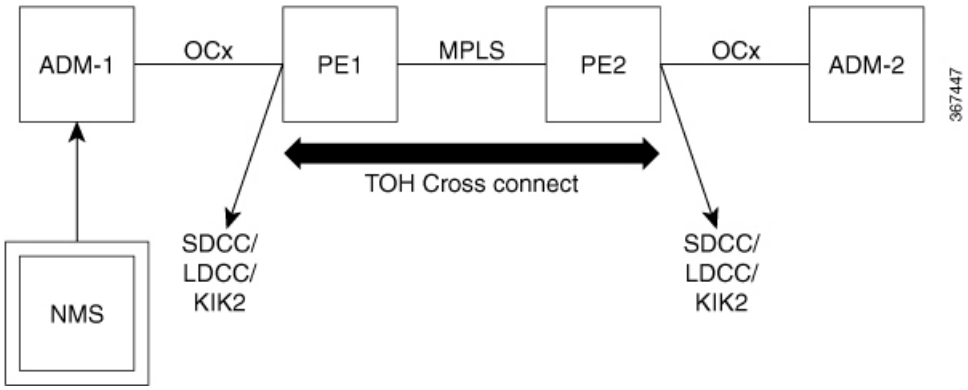
The behavior without DCC tunneling is that the NMS discovers the connected ADM but could not reach the ADM at the remote end of the TDM circuit.

With the introduction of DCC tunneling, the NMS discovers the existing topology and the insertion of ASR nodes are transparent to the DCC bytes. These ASR nodes help to tunnel DCC bytes and the NMS connectivity remains intact.

In the following diagram, the ADM-1 reaches the ADM-2 through transparent overhead (TOH) tunnel that is established between provider edges (PE1 and PE2).

The DCC bytes from ADM-1 reach ADM-2 through the TOH tunnel. Therefore, the NMS could reach the ADM-2 and the topology across ADMs remains intact.

Figure 10: Transparent Overhead Tunneling-SONET



TOH tunneling DCC is supported on the OCx ports for following CEM interface modules:

- 1-port OC-48/STM-16 or 4-port OC-12/OC-3 / STM-1/STM-4 + 12-port T1/E1 + 4-port T3/E3 module
- 1-port OC-192 or 8-port low rate module
- ASR 900 1-port OC-192 or 8-port low rate CEM 20G bandwidth module

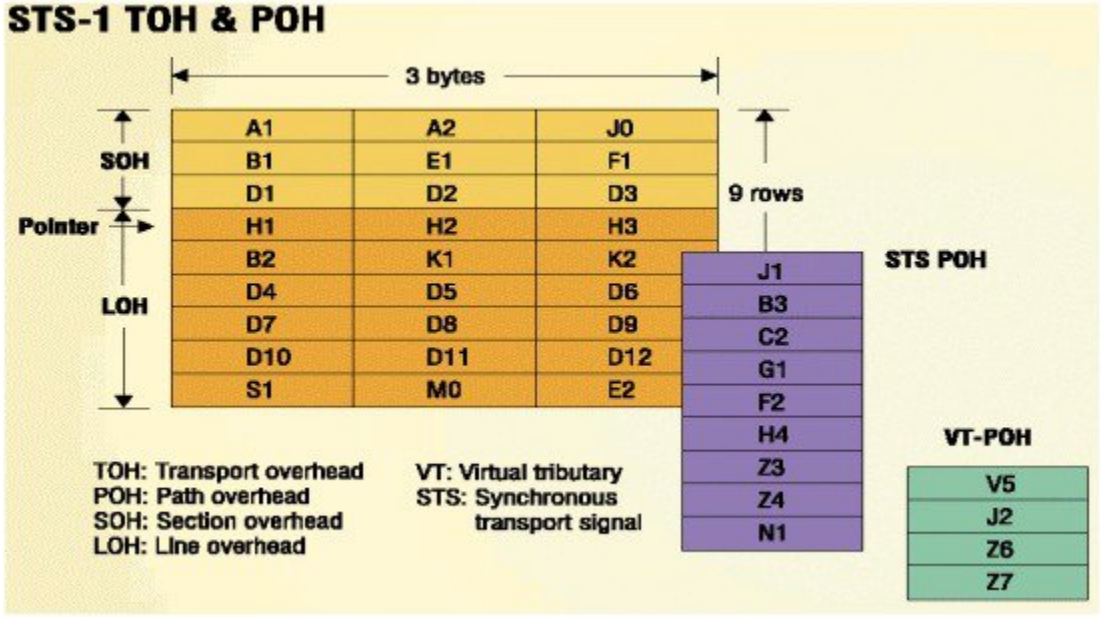
Transparent Overhead Tunnel DCC Types

The transparent overhead tunnel supports the following DCC types that are embedded in the transport overhead of STS-1 frame:

- Section DCC—Supports 3 bytes, D1, D2, and D3 responsible for message-based administration, monitoring, alarm maintenance, and other communication requirements. The section DCC provides a bandwidth of 192 Kbit/s between each pair of SONET section termination equipment. Any SONET equipment that can extract these 3 bytes from the STS-1 frame overhead and process them is considered to support a DCC interface.
- Line DCC—Supports D4 to D12 bytes with bandwidth of 576 Kbit/s.

In the following diagram, STS-1 Transport and Path Overhead are displayed.

Figure 11: STS-1 Frame Structure



The following table describes the transparent overhead tunnel segments with the supported tunnel types and the respective tunnel header bytes.

Table 46: Tunnel Segments with Tunnel Types and Supported Header Bytes

Tunnel Segment	Tunnel Type	Header Bytes
Section Header	SDCC for SONET RS-DCC for SDH	D1, D2, D3
Section Header	SOH	E1, F1, D1, D2, D3
Line Header	K1K2	K1K2
Line Header	LDCC for SONET MS-DCC for SDH	D4 to D12
Line Header	LOH	K1, K2, D4 to D12, E2
Section and Line Header	ALL	E1, F1, D1, D2, D3, K1, K2, D4 to D12, M0, E2

Prerequisites for Transparent Overhead Tunnel

Before creating transparent overhead tunnel, ensure that you perform the following steps:

- Set mode under the STS path for SONET before enabling the overhead tunnel.

  The following example details on how to set STS-1 mode on SONET.

```
platform enable controller MediaType 0/3/2 oc3
controller MediaType 0/3/2
 mode sonet
controller SONET 0/3/2
 rate OC3
 no ais-shut
 alarm-report all
 clock source internal
 !
 sts-1 1
  clock source internal
  mode vt-15
```

- Set mode under the AU-4 path on SDH before enabling the overhead tunnel.

  The following example details on how to set AU-4 mode on SDH.

```
platform enable controller MediaType 0/3/2 stm1
controller MediaType 0/3/2
 mode sdh
controller SDH 0/3/2
 rate STM1
 no ais-shut
 alarm-report all
 clock source internal
 aug mapping au-4
 au-4 1
  clock source internal
  channel-group 0
  mode vc4
```

- Mode and TOH type must be same on both PEs in an end-to-end setup.

  For example, if the PE-1 device has mode that is configured as VT-15 and TOH type as SDCC, then the same mode and TOH type must be configured on the PE-2 device.

  If the mode and TOH type configurations differ, then the TOH tunneling does not work.

Limitations of Transparent Overhead Tunnel

The following limitations apply to the transparent overhead tunnel:

- Ensure that mode is set under the path level of SONET or SDH interface before configuring the tunnel.
- If the DCC interface is configured, then DCC tunneling cannot be configured. You can configure either one of them at a time.
- TOH tunnel configuration is supported only at the port level.
- QoS is not supported for TOH channels.
- Each interface module in IO-FPGA supports only 9 TOH channels.
- When a TOH tunnel is configured with a specific CEM group and CEM identifier on an interface, then to modify the CEM group, you must perform the following steps:

  1. First remove the TOH tunnel that is configured on that interface using the **no overhead tunnel** *tunnel-type cem-group cem-id* command.
  2. Then add with a new CEM group and CEM identifier.

- When DCC tunneling is set, you cannot configure payload and dejitter buffer under the CEM interface.
- The K1 and K2 bytes are not transparent over APS-enabled channels.

How to Configure Transparent Overhead Tunnel

This section provides information about configuring the transparent overhead tunnel.

Configuring Mode for Controller

Configuring Mode for SONET Controller

Before configuring transparent overhead tunnel, ensure that mode for the controller is configured.

To configure mode for the SONET controller, use the following commands:

```
controller sonet interface
sts-1 1
  mode vt-15
end
```

Configuring Mode for SDH Controller

To configure mode for the SDH controller, use the following commands:

```
controller sdh interface
aug mapping au-4
au-4 1
clock source internal
channel-group 0
mode vc4
end
```



Note Any path-level mode can be set for SONET or SDH.

Creating Transparent Overhead Tunnel

To configure a transparent overhead tunnel, specify the tunnel type of the line or section header and CEM group with identifier.

To configure the transparent overhead tunnel on the SONET interface, use the following commands:

```
router(config)#controller sonet interface-name
router(config-controller)#overhead tunnel <All | SDCC | LDCC | K1K2 | LOH | SOH> cem-group
 cem-id unframed
router(config-controller)#end
```

To configure the transparent overhead tunnel on the SDH interface, use the following commands:

```
router(config)#controller sdh interface-name
router(config-controller)#overhead tunnel <All | RS-DCC | MS-DCC | K1K2 | LOH | SOH> cem-group
```

```
 cem-id unframed
router(config-controller)#end
```

Configuring DCC Interface in IP Domain

To configure DCC Interface in IP domain controller, use the following commands:

```
router ospf 100
interface sdcc/ldcc


encapsulation ppp
ip address 10.2.2.1 255.0.0.0
crc <16/32 >
ip ospf 100 area 0
```

Configuring TOH Tunnelling

To configure TOH Tunnelling use the following commands:

```
controller SONET/SDH < >
 no snmp trap link-status
 rate < >
 no ais-shut
 alarm-report all
 clock source internal
 overhead tunnel sdcc/ldcc/k1k2/soh/toh/all/aps_all cem-group 0 unframed
```

Creating Transparent Overhead Tunnel Pseudowire

To configure a transparent overhead tunnel pseudowire, first configure the CEM interface and then perform cross connect to a peer device with a remote IP address and specific virtual circuit identifier using MPLS encapsulation. The pseudowire carry forward specific TOH types as configured.

To configure the transparent overhead tunnel pseudowire, use the following commands:

```
router(config)#interface cem 0/3/4
router(config-if)#cem cem-id
router(config-if)#xconnect  remote-ip-address  virtual-connect-ID  encapsulation MPLS
router(config-controller)#end


router(config)#interface cem 0/3/4
router(config-if)#cem 1
router(config-if)#xconnect   192.168.0.2  2  encapsulation MPLS
router(config-controller)#end
```

Verifying Transparent Overhead Tunnel and Pseudowire Configuration

The following **show cem circuit interface cem** *interface-name* command displays that CEM interface is configured for a transparent overhead tunnel.

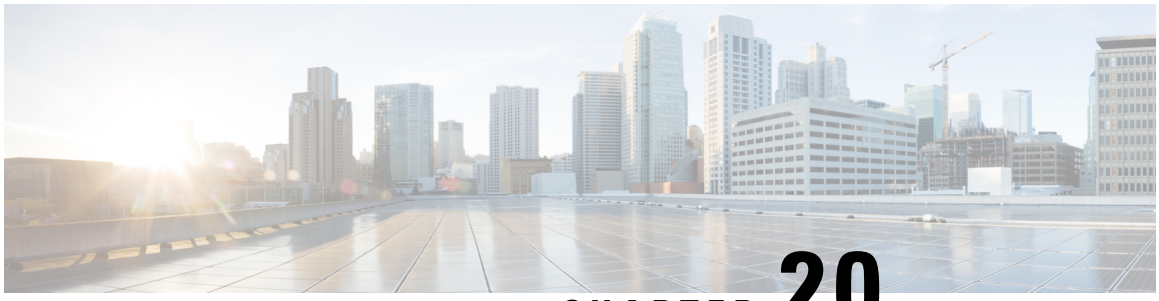
```
Router# show cem circuit interface cem 0/7/7
CEM0/7/7, ID: 100, Line: UP, Admin: UP, Ckt: ACTIVE,   TOH Type: LOH
Controller state: up
Idle Pattern: 0xFF, Idle CAS: 0x8
Dejitter: 6 (In use: 0)
```

```
Payload Size: 8
Framing: Unframed
CEM Defects Set
None

Signalling: No CAS
RTP: No RTP

Ingress Pkts:    3001                Dropped:             0
Egress Pkts:     3001                Dropped:             0

CEM Counter Details
Input Errors:    0                   Output Errors:       0
Pkts Missing:    0                   Pkts Reordered:      0
Misorder Drops:  0                   JitterBuf Underrun:  0
Error Sec:       0                   Severly Errored Sec: 0
Unavailable Sec: 0                   Failure Counts:      0
Pkts Malformed:  0                   JitterBuf Overrun:   0
Generated Lbits: 0                   Received Lbits:      0
Generated Rbits: 0                   Received Rbits:      0
```



CHAPTER 20

Target Identifier Address Resolution Protocol

Some appications running on SONET devices identify these devices by a Target Identifier (TID). Therefore, it is necessary for the router to cache TID-to-network address mappings. As these devices usually run over OSI, the network addresses involved in the mapping are OSI Network Service Access Points (NSAP).

When a device sends a packet to another device, the device needs a way to request this information directly from the device, or from an intermediate device in the network. This functionality is provided by an address resolution protocol called TID Address Resolution Protocol (TARP).

Service providers need a dynamic method to map TIDS to NSAPs, and TARP serves this purpose. TARP runs over the Connectionless Network Protocol (CLNP) as a router must support CLN Service Routing to support TARP.

- Prerequisites for TARP Support, on page 307
- Restrictions and Limitations, on page 307
- Types of TARP PDU's, on page 308
- TARP Features, on page 308
- How To Configure TARP, on page 311
- Configuring TARP Features, on page 314

Prerequisites for TARP Support

If the router is configured as an IS, the router must be running IS-IS.

If the router is configured as an ED, then the router must be running ES-IS.

Restrictions and Limitations

- The commands “tarp allow caching” and “no tarp allow caching” may result in tarp resolution failures.
- Configuring multiple NSAP addresses are not supported.
- Avoid multiple configuring or changing tid and NSAP.

Types of TARP PDU's

- Type 1—Sent when a device has a TID for which it has no matching NSAP. Type 1 PDUs are sent to all Level 1 (IS-IS and ES-IS) neighbors. If no response is received within the specified time limit, a Type 2 PDU is sent. To prevent packet looping, a loop detection buffer is maintained on the router. A Type 1 PDU is sent when you use the **tarp resolve** command.

  A Type 1 PDU is sent when a device has a TID for which it has no matching NET information and is sent to all L1 neighbors. When a device receives a Type 1 PDU, it checks if the PDU matches the target TID of the device. When they match, a type 3 PDU is created and unicasted directly to the sender of the TARP PDU. In addition, if the update remote cache is set in the incoming PDU, the receiver updates (or creates) the cache entry for the originator. If the target TID does not match, the device propagates this PDU to all its L1 neighbors (except the originator of this PDU). If no response is received within the timeout period (15 seconds), a Type 2 PDU is originated.

  To prevent packet looping, a Loop Detection Buffer (LDB) is maintained. This consists of system ID - sequence number mappings. A packet is discarded if its sequence number is less than or equal to that found in the LDB for this system ID. If no entry is present, the LDB is updated, and the packet is processed. A sequence number of zero is treated specially, and will cause the entry in the cache to be superseded.

- Type 2—Sent when a device has a TID for which it has no matching NSAP and no response was received from a Type 1 PDU. Type 2 PDUs are sent to all Level 1 and Level 2 neighbors. A time limit for Type 2 PDUs can also be specified. A Type 2 PDU is sent when you use the **tarp resolve** command and specify the option 2.

  A Type 2 PDU is same as a Type 1, except that this PDU is sent to all (L1 and L2) neighbors. The default timeout is 25 seconds.

- Type 3—Sent as a response to a Type 1, Type 2, or Type 5 PDU. Type 3 PDUs are sent directly to the originator of the request.

- Type 4—Sent as a notification when a change occurs locally (for example, a TID or NSAP change). A Type 4 PDU usually occurs when a device is powered up or brought online.

- Type 5—Sent when a device needs a TID that corresponds to a specific NSAP. Unlike Type 1 and Type 2 PDUs that are sent to all Level 1 and Level 2 neighbors, a Type 5 PDU is sent only to a particular router. In addition to the type, TARP PDUs contain the sender NSAP, the sender TID, and the target TID (if the PDU is a Type 1 or Type 2). A Type 5 PDU is sent when you use the **tarp query** command.

TARP Features

The following are the features of TARP:

TARP Caching

TID - Network addresses mappings are stored in a cache, implemented as a hash table. A cache entry can be created dynamically when a router hears from another TARP device (e.g. as a result of a query addressed to the router), or statically via TARP "map" commands. All dynamically created TARP cache entries (i.e. those that are not static or flagged as "LOCAL") are aged out. The time out value is configurable.

TARP Timers

Configure the amount of time that the router waits to receive a response from a Type 1 PDU, a Type 2 PDU, and a Type 5 PDU and also configure the lifetime of the PDU based on the number of hops.

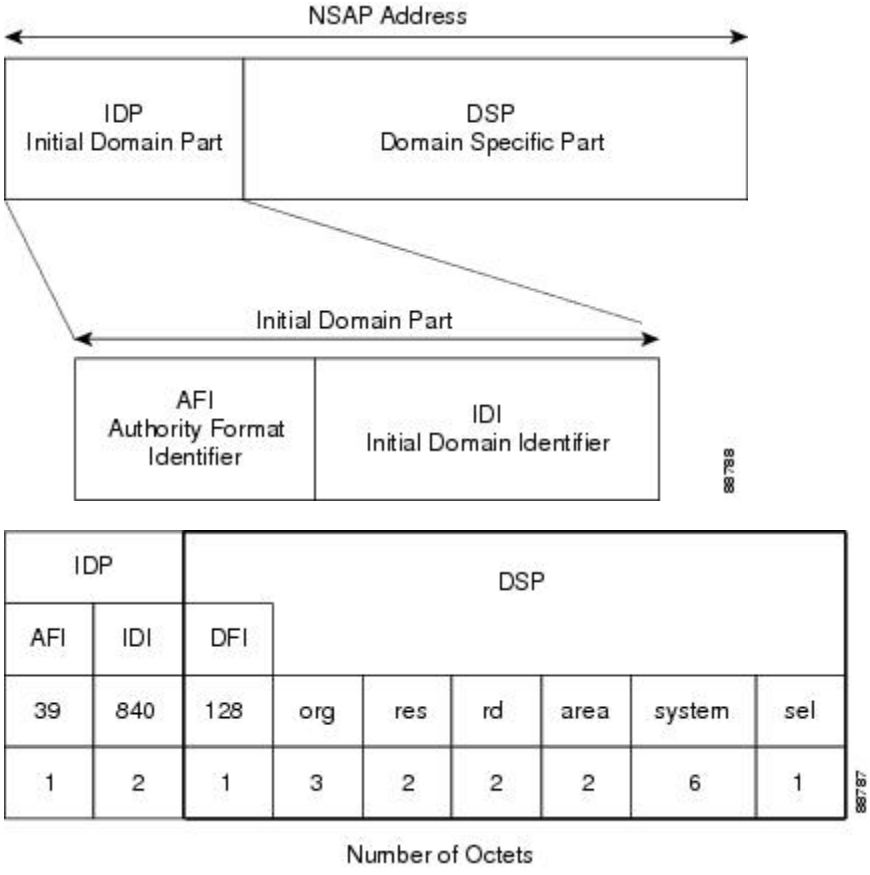
Set timers that control how long dynamically created TARP entries remain in the TID cache, and how long the system ID-to-sequence number mapping entry remains in the loop detection buffer table. The loop detection buffer table prevents TARP PDUs from looping.

TARP Counters

TARP will maintain a list of useful counters, and will increment the relevant counter. There will also be extensive debugging support that will facilitate troubleshooting

NSAP Address Format

The OSI network address is referred to as a network service access point (NSAP). The NSAP is assigned to the end system (ES) or intermediate system (IS) device. Unlike in IP, which has an address for every network interface, the OSI network device receives only one address, the NSAP address. The NSAP address has two parts, the Initial Domain Part (IDP) and Domain Specific Part (DSP).



Determining TIDs and NSAPs

To determine an NSAP address for a TID or a TID for an NSAP address, use the following commands in EXEC mode:

Command	Purpose
Router # **tarp query** *nsap*	Gets the TID associated with a specific NSAP.
Router # **tarp resolve** *neighbour tid*	Gets the NSAP associated with a specific TID.

To determine the TID, the router first checks the local TID cache. If there is a TID entry in the local TID cache, the requested information is displayed. If there is no TID entry in the local TID cache, a TARP Type 5 PDU is sent out to the specified NSAP address.

To determine the NSAP address, the router first checks the local TID cache. If there is an NSAP entry in the local TID cache, the requested information is displayed. If there is no NSAP entry in the local TID cache, a TARP Type 1 or Type 2 PDU is sent out. By default, a Type 1 PDU is sent to all Level 1 (IS-IS and ES-IS) neighbors. If a response is received, the requested information is displayed. If a response is not received within the response time, a Type 2 PDU is sent to all Level 1 and Level 2 neighbors. Specifying the **tarp resolve** *tid 2* EXEC command causes only a Type 2 PDU to be sent.

You can configure the length of time that the router will wait for a response (in the form of a Type 3 PDU).

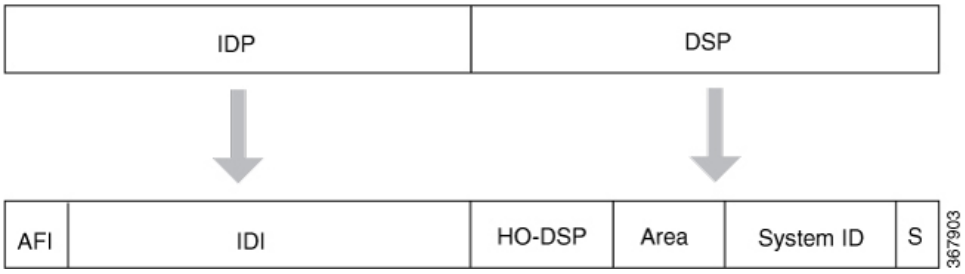
Understanding NSAP

Addresses in the ISO network architecture are referred to as network service access point (NSAP)addresses and network entity titles (NETs). Each node in an OSI network has one or more NETs. In addition, each node has many NSAP addresses. Each NSAP address differs from one of the NETs for that node in only the last byte. This byte is called the N-selector. Its function is similar to the port number in other protocol suites.

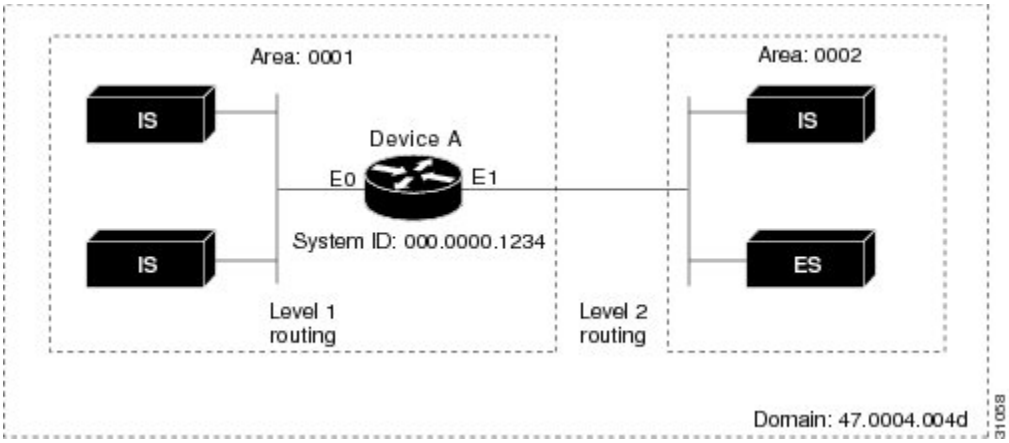
Our implementation supports all NSAP address formats that are defined by ISO 8348/Ad2; however, Cisco provides ISO Interior Gateway Routing Protocol (IGRP) or Intermediate System-to-Intermediate System (IS-IS) dynamic routing only for NSAP addresses that conform to the address constraints defined in the ISO standard for IS-IS (ISO 10589).

An NSAP address consists of the following two major fields, as shown in Figure 1:

- The initial domain part (IDP) is made up of 1-byte authority and format identifier (AFI) and a variable-length initial domain identifier (IDI). The length of the IDI and the encoding format for the domain specific part (DSP) are based on the value of the AFI.
- The DSP is made up of a High Order DSP (HO-DSP), an area identifier, a system identifier, and a 1-byte N-selector (labeled S).



Assign addresses or NETs for your domains and areas. The domain address uniquely identifies the routing domain. All routers within a given domain are given the same domain address. Within each routing domain, you can set up one or more areas, as shown in Figure 2. Determine which routers are to be assigned to which areas. The area address uniquely identifies the routing area and the system ID identifies each node.



The key difference between the ISO IGRP and IS-IS NSAP addressing schemes is in the definition of area addresses. Both use the system ID for Level 1 routing (routing within an area). However, they differ in the way addresses are specified for area routing. An ISO IGRP NSAP address includes three separate fields for routing: the domain, area, and system ID. An IS-IS address includes two fields: a single continuous area field (comprising the domain and area fields) and the system *ID*.

How To Configure TARP

To configure TARP on the router, perform the tasks in the following sections:

Enabling TARP and Configuring a TARP TID

TARP must be explicitly enabled before the TARP functionality becomes available, and the router must have a TID assigned. Also, before TARP packets can be sent out on an interface, each interface must have TARP enabled and the interface must be able to propagate TARP PDUs.

The router will use the CLNS capability to send and receive TARP PDUs. If the router is configured as an IS, the router must be running IS-IS. If the router is configured as an ES, the router must be running ES-IS.

To turn on the TARP functionality, use the following commands in global configuration mode:

Command	Purpose
Router(config)# **tarp run**	Turns on the TARP functionality.
Router(config)# **tarp tid** *tid*	Assigns a TID to the router.

To enable TARP on one or more interfaces, use the following command in interface configuration mode

Table 47:

Command	Purpose
Router(config-if)# **tarp enable**	Enables TARP on the interface.

TARP on Gigabit Ethernet Interface

The following example shows how to enable TARP on the router and Ethernet interface 0. The router is assigned the TID name.

```
interface GigabitEthernet0/2/5
ip address 172.16.1.2 255.240.0.0 àip address for gig
ip router isis 1 -- to enable the isis configured under gig
negotiation auto
clns router isis 1 --- to assign it to clns
isis circuit-type level-1 --- isis level type
tarp enable
```

TARP on SDCC

The following example shows how to enable TARP on the SDCC interface. The router is assigned the TID name.

```
interface SDCC0/3/3
ip address 192.168.10.7 255.255.0.0
encapsulation lapd
lapd t200 200
lapd role user
'lapd role network' by default
clns mtu 512
clns router isis 1
isis circuit-type level-1
no isis hello padding
isis retransmit-interval 10
isis lsp-interval 512
tarp enable

tunnel source GigabitEthernet0/4/7
interface GigabitEthernet0/4/7
ip address 172.16.1.1 255.240.0.0
negotiation auto

Router#sh run | sec Tunnel1
interface Tunnel1
ip address 172.16.2.2 255.240.0.0
ip router isis 1
```

```
tunnel source GigabitEthernet0/4/7
tunnel destination 192.168.1.2
clns router isis 1
isis circuit-type level-1
tarp enable
```

For more information on SDCC, Configuring Data Communication Channel

How to Configure TARP

TARP must be explicitly enabled before the TARP functionality becomes available, and the router must have a TID assigned. Also, before TARP packets can be sent out on an interface, each interface must have TARP enabled and the interface must be able to propagate TARP PDUs.

The router uses the CLNS capability to transfer and receive TARP PDUs. If the router is configured as an IS, the router must be running IS-IS. If the router is configured as an ES, the router must be running ES-IS.

TARP feature can be optionally enabled or disabled through CLI. Furthermore, all interfaces over which TARP packets that need to be sent must have TARP configured. Propagation of TARP packets can be disabled on an interface basis, on an adjacency basis, or on a global basis. Origination of TARP packets can be disabled on a global basis.

To configure TARP on a Gigabit Ethernet Interface, use the following commands:

Procedure

Step 1 **configure terminal**

Enter global configuration mode.

Step 2 **tarp run**

```
Router (config)# tarp run
```

Enable TARP functionality.

Step 3 **tarp tid** *id*

```
Router (config)# tarp tid 500
```

Assign TID to the router.

Step 4 **tarp enable** *interface name*

```
Router (config)#tarp enable Te0/12/0
```

Enables TARP on an interface.

TARP Configuration Examples

The following example shows how to enable TARP on the router and Ethernet interface 0. The router is assigned the TID myname.

```
clns routing
 tarp run
```

```
tarp tid myname

interface ethernet 0
 tarp enable
```

Configuring TARP Features

To configure TARP features on the router, perform the tasks in the following sections.

Configuring Static TARP Adjacency and Blacklist Adjacency

In addition to all its IS-IS/ES-IS adjacencies, a TARP router propagates PDUs to all its static TARP adjacencies. If a router is not running TARP, the router discards TARP PDUs rather than propagating the PDUs to all its adjacencies. To allow TARP to bypass routers en route that may not have TARP running, TARP provides a static TARP adjacency capability. Static adjacencies are maintained in a special queue.

To create a static TARP adjacency, use the following command in global configuration mode:

Command	Purpose
Router(config)# **tarp route-static** *nsap* **[all | message-type {unknowns** | type-number} [type-number] [type-number]]	Enters a static TARP adjacency.

To stop TARP from propagating PDUs to an IS-IS/ES-IS adjacency that may not have TARP running, TARP provides a blacklist adjacency capability. The router will not propagate TARP PDUs to blacklisted routers. To blacklist a router, use the following command in global configuration mode:

To blacklist a router, use the following command in global configuration mode:

Command	Purpose
Router(config)# **tarp blacklist-adjacency** *nsap*	Bypasses a router not running TARP.

Configuring TARP Timers

TARP timers provide default values and typically need not be changed.

You can configure the amount of time that the router waits to receive a response from a Type 1 PDU, a Type 2 PDU, and a Type 5 PDU. You can also configure the lifetime of the PDU based on the number of hops.

You can also set timers that control how long dynamically created TARP entries remain in the TID cache, and how long the system ID-to-sequence number mapping entry remains in the loop detection buffer table. The loop detection buffer table prevents TARP PDUs from looping.

To configure TARP PDU timers, control PDU lifetime, and set how long entries remain in cache, use the following commands in global configuration mode:

Command	Purpose
Router(config)# **tarp t1-response-timer** *seconds*	Configures the number of seconds that the router will wait for a response from a TARP Type 1 PDU.

Command	Purpose
Router(config)# **tarp t2-response-timer** *seconds*	Configures the number of seconds that the router will wait for a response from a TARP Type 2 PDU.
Router(config)# **tarp post-t2-response-timer** *seconds*	Configures the number of seconds that the router will wait for a response from a TARP Type 2 PDU after the default timer has expired.
Router(config)# **tarp arp-request-timer** *seconds*	Configures the number of seconds that the router will wait for a response from a TARP Type 5 PDU.
Router(config)# **tarp lifetime** *hops*	Configures the number of routers that a TARP PDU can traverse before it is discarded.
Router(config)# **tarp cache-timer** *seconds*	Configures the number of seconds a dynamically created TARP entry remains in the TID cache.
Router(config)# **tarp ldb-timer** *seconds*	Configures the number of seconds that a system ID-to-sequence number mapping entry remains in the loop detection buffer table.

Configuring Miscellaneous TARP PDU Information

TARP default PDU values typically need not be changed.

You can configure the sequence number of the TARP PDU, set the update remote cache bit used to control whether the remote router updates its cache, specify the N-selector used in the PDU to indicate a TARP PDU, and specify the network protocol type used in outgoing PDUs.

To configure miscellaneous PDU information, use the following commands in global configuration mode:

Table 48:

Command	Purpose
Router(config)# **tarp sequence-number** *number*	Changes the sequence number in the next outgoing TARP PDU.
Router(config)# **tarp urc [0 | 1]**	Sets the update remote cache bit in all subsequent outgoing TARP PDUs so that the remote router does or does not update the cache.
Router(config)# **tarp nselector-type** *hex-digit*	Specifies the N-selector used to identify TARP PDUs.
Router(config)# **tarp protocol-type***hex-digit*	Specifies the protocol type used in outgoing TARP PDUs. Only the hexadecimal value 0xFE (to indicate the CLNP) is supported.

TARP Configuration Task List

To configure TARP on the router, perform the tasks in the following sections. Only the first task is required; all other tasks are optional.

Disabling TARP Caching

By default, TID-to-NSAP address mappings are stored in the TID cache. Disabling this capability clears the TID cache. Reenabling this capability restores any previously cleared local entry and all static entries.

To disable TID-to-NSAP address mapping in the TID cache, use the following command in global configuration mode:

Command	Purpose
Router(config)# **no tarp allow-caching**	Disables TARP TID-to-NSAP address mapping.

Disabling TARP PDU Origination and Propagation

By default, the router originates TARP PDUs and propagates TARP PDUs to its neighbors, and the interface propagates TARP PDUs to its neighbor. Disabling these capabilities means that the router no longer originates TARP PDUs, and the router and the specific interface no longer propagate TARP PDUs received from other routers.

To disable origination and propagation of TARP PDUs, use the following commands in global configuration mode:

Command	Purpose
Router(config)# **no tarp originate**	Disables TARP PDU origination.
Router(config)# **no tarp global-propagate**	Disables global propagation of TARP PDUs.

To disable propagation of TARP PDUs on a specific interface, use the following command in interface configuration mode:

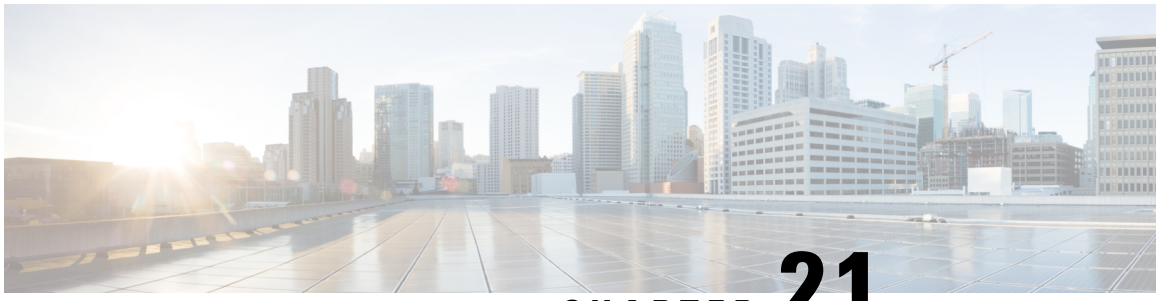
Command	Purpose
Router(config-if)# **no tarp propagateall | message-type {unknowns***type-number} [type-number] [type-number]]*	Disables propagation of TARP PDUs on the interface.



PART VI

Bandwidth for OCx Modules

- Configuring 5G Mode, on page 319



CHAPTER 21

Configuring 5G Mode

Effective Cisco IOS XE Everest 16.5.1, 5G mode is supported on 1-Port OC-192/STM-64 or 8-Port OC-3/12/48/STM-1/-4/-16 Interface Module. Previously, only 10G mode was supported. 5G mode is supported on those interface module slots that do not support 10G mode.

On the ASR 907 Routers, if the interface module is inserted in the slots 3, 4, 7, 8, 11, or 12, the interface module comes up in 10G mode by default. Use the mode conversion command to use the interface module in 5G mode. If the interface module is inserted in the slots 2, 5, 6, 9, 10, 13, 14, and 15, the interface module comes up in 5G mode by default. Hence, there is no need to apply the mode conversion command.

Note Slot 1 on the ASR 907 Router is supported for the 5G mode for 1-Port OC-192/STM-64 or 8-Port OC-3/12/48/STM-1/-4/-16 Interface module on the chassis.

Note OC-192/STM-64 port is disabled in 5G mode.

Table 49: Default 5G Slots on ASR 903 Routers

Bays	Interface Module Support	Default Mode	5G Mode Command Support
0	No	No	No
1	No	No	No
2	Yes	10G_CEM	Yes
3	Yes	10G_CEM	Yes
4	Yes	10G_CEM	Yes
5	Yes	10G_CEM	Yes

Table 50: Default 10G Slots on ASR 907 Routers

Bays	Interface Module Support	Default Mode	5G Mode Command Support
0	No	No	No
1	No	No	No
2	Yes	5G_CEM	No need to use the command as the interface module is in 5G mode by default
3	Yes	10G_CEM	Yes
4	Yes	10G_CEM	Yes
5	Yes	5G_CEM	No need to use the command as the interface module is in 5G mode by default
6	Yes	5G_CEM	No need to use the command as the interface module is in 5G mode by default
7	Yes	10G_CEM	Yes
8	Yes	10G_CEM	Yes
9	Yes	5G_CEM	No need to use the command as the interface module is in 5G mode by default
10	Yes	5G_CEM	No need to use the command as the interface module is in 5G mode by default
11	Yes	10G_CEM	Yes
12	Yes	10G_CEM	Yes
13	Yes	5G_CEM	No need to use the command as the interface module is in 5G mode by default

Bays	Interface Module Support	Default Mode	5G Mode Command Support
14	Yes	5G_CEM	No need to use the command as the interface module is in 5G mode by default
15	Yes	5G_CEM	No need to use the command as the interface module is in 5G mode by default

Features of the Interface Module:

- This IM supports 8 ports with 5G CEM traffic.
- This IM supports a maximum of 5Gbps traffic throughput with the following services:
  - 5G HO CEP
  - 5G LO CES/CEP

- Supported Traffic Combinations, on page 321
- Restrictions for Configuring 1-Port OC-192/STM-64 or 8-Port OC-3/12/48/STM-1/-4/-16 Interface Module, on page 322
- Important Notes on Configuration, on page 322
- Configuring 5G Mode from 10G Mode, on page 322
- Configuring 10G Mode from 5G Mode, on page 322
- Verification of 5G Traffic Configuration, on page 323
- Associated Commands, on page 323

Supported Traffic Combinations

The following traffic combination is supported:

- **CEM Traffic - SONET**:

  Ports 0-7 are available as OC-48/OC-12/OC-3/1GE ports. To achieve 5G traffic on the card, four ports are grouped. For example, 0-3 and 4-7 can provide a maximum traffic of 2.5G. For example, OC-48 port is allocated in each group. Hence, if one of the ports is configured as OC-48, the other ports in the group cannot be configured. If OC-12 or OC-3 rate is configured in any of the port groups, OC-48 cannot be configured.

- **CEM Traffic - SDH**:

  Ports 0-7 are available as STM-16, STM-4, and STM-1 ports. To achieve 5G traffic on the card, four ports are grouped. For example, 0-3 and 4-7 can provide a maximum traffic of 2.5G. For example, STM-16 port is allocated in each group. Hence, if one of the ports is configured as STM-16, the other ports in the group cannot be configured. If STM-4 or STM-1 rate is configured in any of the port groups, STM-16 cannot be configured.

Restrictions for Configuring 1-Port OC-192/STM-64 or 8-Port OC-3/12/48/STM-1/-4/-16 Interface Module

- There should not be any configuration before the mode conversion command is used.
- The IM reloads and becomes active only about 5 minutes after a mode conversion is complete.
- When the mode changing command is applied by copying from a file (from TFTP server), the IM reloads and as a result all subsequent configurations fail for that interface module. You must change the mode of the interface module to 5G mode or 10G before copying the configurations from the TFTP file.
- For 10G mode, port 8 is used to configure OC-192 or STM-64 rate. You cannot use port 8 in 5G mode.

Important Notes on Configuration

- There should not be any of the following configurations before the **mode conversion** command is used:
  - CEM configurations
  - Path configurations
  - Mode SONET configuration under controller Mediatype
  - Mode SDH configuration under controller Mediatype
- When the **mode conversion** command is applied, the interface module reloads and becomes active after 5 minutes after a mode conversion is complete.
- When mode changing command is applied by copying from a file (from TFTP server), the IM reloads and as a result subsequent configurations fail for that IM. hence, you should change the mode of the interface module to 5G mode or vice versa before copying the configurations from the TFTP file.
- The interface module must be in shutdown state while upgrading from XLAUI mode to XFI passthrough mode.

Configuring 5G Mode from 10G Mode

To configure 5G mode from 10G mode:

```
enable
configure terminal
platform hw-module configuration
hw-module <slot> / <subslot> <PID> mode 5G_CEM
end
```

Configuring 10G Mode from 5G Mode

To configure 10G mode from 5G mode:

```
enable
configure terminal
platform hw-module configuration
hw-module <slot> / <subslot> <PID>
end
```

Verification of 5G Traffic Configuration

Use the **show running configuration** command to verify 5G traffic configuration:

```
Router#show running-config  | include mode
hw-module 0/bay PID mode 5G_CEM
Router#
```

Associated Commands

The following table shows the associated commands for 5G traffic configuration:

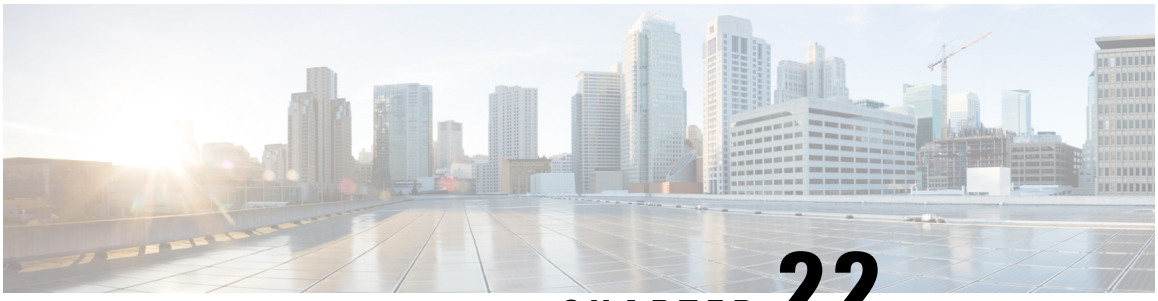
Commands	Links
hw-module mode	http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/mcl/allreleasemcl/all-book/all-06.html
platform hw-module configuration	http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/mcl/allreleasemcl/all-book/all-10.html
show running configuration | include mode	http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/mcl/allreleasemcl/all-book/all-14.html



PART VII

Additional References

- Additional References for SONET/SDH Frame Structures, on page 327



CHAPTER 22

Additional References for SONET/SDH Frame Structures

This section provides information about STS-1 and STS-3 frame structures for SONET with concatenated and channelized details, and STM-1 frame with VC details for SDH frame.

For more information on the basic CEM features such as CEM classes and CEM parameters (payload size and dejitter buffer), configuration, and verfication, see the CEM Generic Configuration Guide, Cisco IOS XE 17 (Cisco ASR 900 Series).

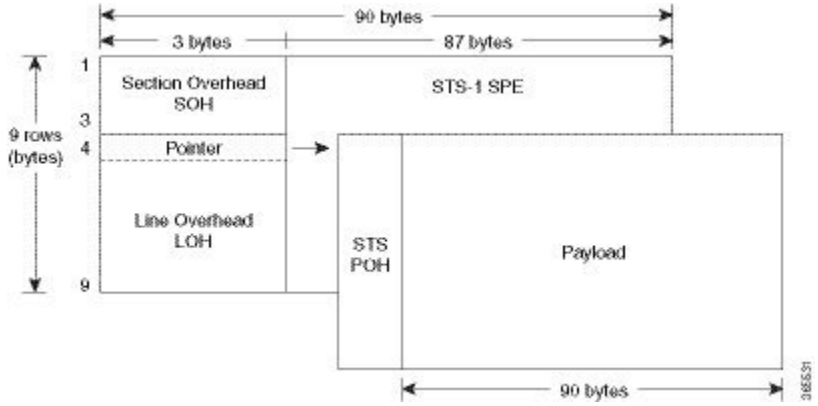
- SONET Frame Structure, on page 327
- SDH Frame Structure, on page 329

SONET Frame Structure

STS-1 and STS-3 Frames

A standard STS-1 frame is nine rows by 90 bytes. The first three bytes of each row represent the Section and Line overhead. These overhead bits comprise framing bits and pointers to different parts of the SONET frame.

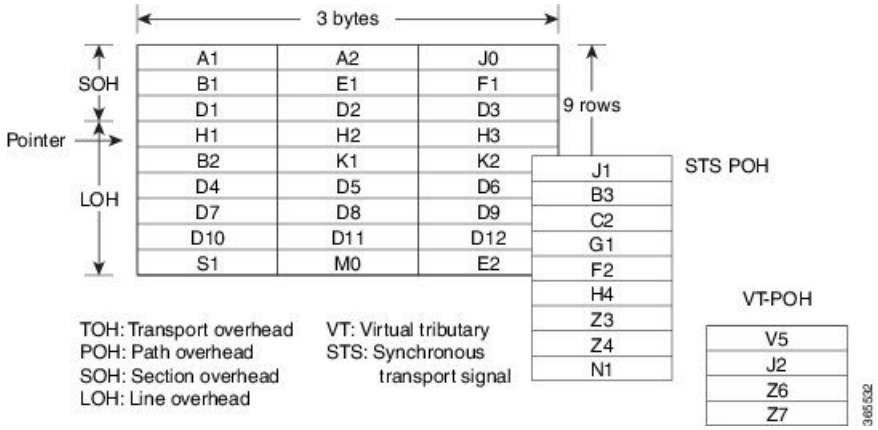
Figure 12: STS-1 Frame Structure



There is one column of bytes in the payload that represents the STS path overhead. This column frequently "floats" throughout the frame. Its location in the frame is determined by a pointer in the Section and Line overhead.

The combination of the Section and Line overhead comprises the transport overhead, and the remainder is the SPE.

Figure 13: STS-1 SONET Overhead



For STS-1, a single SONET frame is transmitted in 125 microseconds, or 8000 frames per second. 8000 fps * 810 B/frame = 51.84 Mbs, of which the payload is roughly 49.5 Mbs, enough to encapsulate 28 DS-1s, a full DS-3, or 21 CEPT-1s.

An STS-3 frame is nine rows by 270 bytes. The first nine columns contain the transport overhead section, and the rest is SPE. For both STS-3 and STS-3c, the transport overhead (Line and Section) is the same.

For an STS-3 frame, the SPE contains three separate payloads and three separate path overhead fields. In essence, it is the SPE of three separate STS-1s packed together, one after another.

For more information on Section Overhead, Line Overhead, and Path Overhead, refer the following:

- http://www.cisco.com/c/en/us/support/docs/optical/synchronous-digital-hierarchy-sdh/5462-sdh-overview.html
- http://www.cisco.com/c/en/us/support/docs/optical/synchronous-optical-network-sonet/13567-sonet-tech-tips.html
- http://www.cisco.com/c/en/us/tech/optical/synchronous-optical-network-sonet/tsd-technology-support-troubleshooting-technotes-list.html

Concatenated SONET Frames

Twenty-eight VTs make up one STS-1. Three STS-1s made up an STS-3 and so on. Any one byte within the STS frame has a direct relationship to a base VT that helps to make up the STS.

A lower-case "c" in the STS rate stands for "concatenated", and indicates that the interface hardware is not channelized. Examples of concatenated interfaces are STS-3c and STS-12c.

The STS-1s may be concatenated into sets of 3 or 12 or 24 or 48 or 192 to form STS-3c, STS-12c, and so on. The STS-1s may be combined only at specific STS-n boundaries within an OC port.

Channelized SONET Frames

A channelized SONET interface is a composite of lower-speed STS streams. However, a channelized SONET interface maintains the streams as independent frames with unique payload pointers. The frames are simply multiplexed before transmission to increase the carrying capacity of the physical fiber. This process is similar to multiplexing 24 digital signal level 0 channels into a DS1 or multiplexing 28 DS1 streams into a DS3.

SDH Frame Structure

The STM-1 frame is the basic transmission format for SDH. The frame lasts for 125 microseconds, therefore, there are 8000 frames per second. The STM-1 frame consists of overhead plus a Virtual Container (VC) capacity.

The SDH frame consists of 270 columns. The first nine columns of each frame make up the Section Overhead, and the last 261 columns make up the VC capacity. The VC plus the pointers (H1, H2, H3 bytes) are called the Administrative Unit (AU). Carried within the VC capacity, which has its own frame structure of nine rows and 261 columns, is the Path Overhead and the Container. The first column is for Path Overhead; it is followed by the payload container, which can itself carry other containers. VCs can have any phase alignment within the Administrative Unit, and this alignment is indicated by the Pointer in row four. Within the Section Overhead, the first three rows are used for the Regenerator Section Overhead, and the last five rows are used for the Multiplex Section Overhead. The STM frame is transmitted in a byte-serial fashion, row-by-row, and is scrambled immediately prior to transmission to ensure adequate clock timing content for downstream regenerators.

Figure 14: STM1 Frame Structure

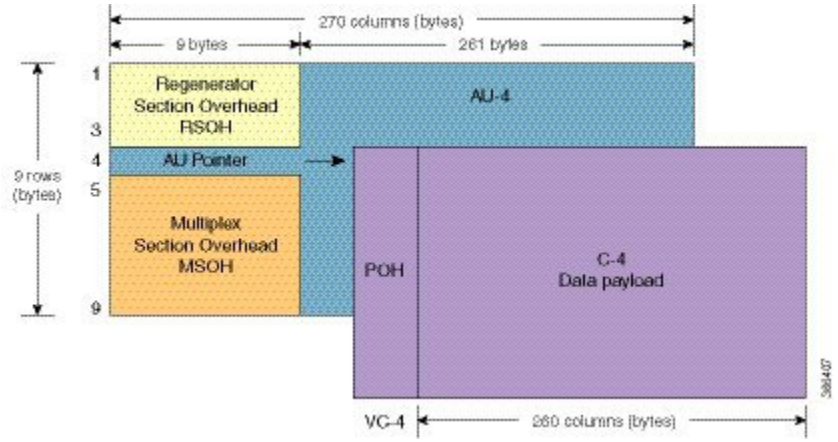
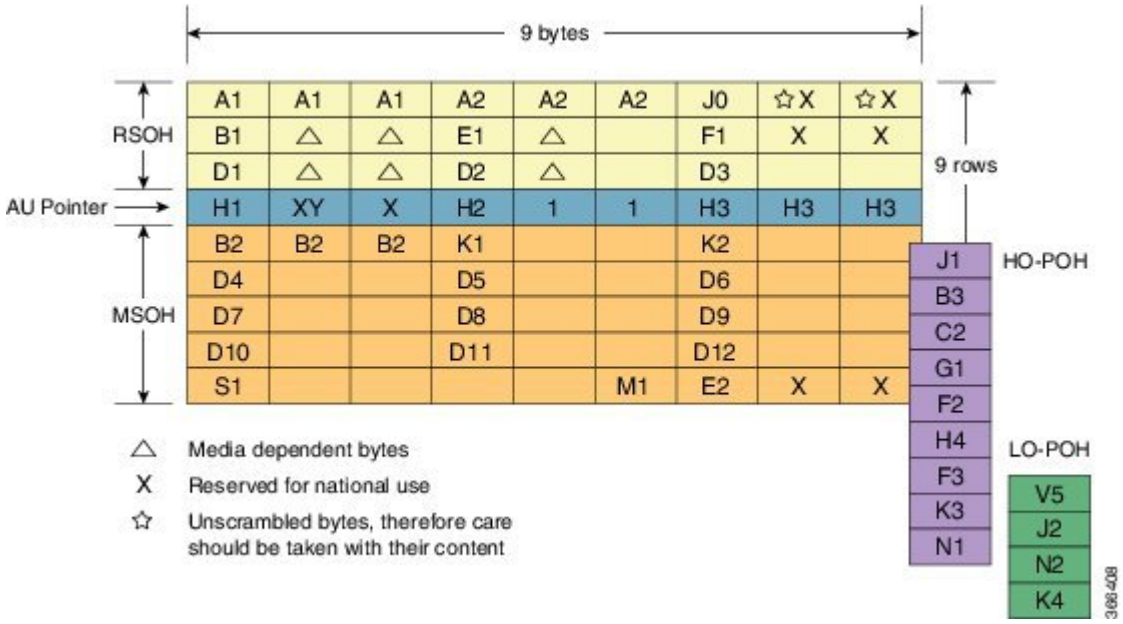


Figure 15: STM1 Section Overhead



VC

SDH supports a concept called VC. Through the use of pointers and offset values, VCs can be carried in the SDH payload as independent data packages. VCs are used to transport lower-speed tributary signals. Note that it can start (indicated by the J1 path overhead byte) at any point within the STM-1 frame. The start location of the J1 byte is indicated by the pointer byte values. VCs can also be concatenated to provide more capacity in a flexible fashion.